MODELLING INTERNATIONAL COMPETITIVENESS: AN ECONOMETRIC APPROACH

By

PATRICK A. ANTOINE

A DISSERTATION PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

UNIVERSITY OF FLORIDA

1992

UNIVERSITY OF FLORIDA LIBRARIES

ACKNOWLEDGEMENTS

There are a number of people without whose assistance this research effort could not have been undertaken. I am grateful for the opportunity to express my appreciation to them all. First and foremost, I feel extremely grateful for having had the opportunity to work with Dr. Taylor. Dr. Taylor's contribution to my studies has gone far beyond his role as chairman of my committee. His professional experience, guidance and friendship have taught me invaluable lessons which I will not soon forget.

I am also indebted to the other members of my committee for their support. Dr. C. Andrew, Dr. L. Cheng, Dr. G. Fairchild and Dr. J. Seale, Jr., gave freely of their advice and assistance. This will always be greatly appreciated.

I wish to thank Dr. T. Vollrath and Dr. E. Ball of USDA, Dr. S. Narayanan of Agriculture Canada and Dr. D. Jorgenson of Harvard University for the provision of data and for their advice. Dr. S. Shonkwiler, Dr. R. Emerson and Dr. C. Moss all assisted me in econometric estimation and I wish to thank them sincerely.

Helpful comments and suggestions were forthcoming from many of my colleagues, teachers and others. In particular, I wish to thank Dr. S. Rao of the Economic Council of Canada, Dr. S. Capalbo of Montana State University, Dr. C. Morrison of Tuffs University, Dr. M. Langham of the University of Florida and Dr. M. Fuss of Toronto University.

I also wish to express my special appreciation to Dr. R. Ward for

his assistance with the computer program. The staff of the Farm Lab, and in particular Mr. B. Heirs and Mr. R. Mack, are also to be heartily thanked for their support in word processing.

My sincere appreciation is extended to my aunt Sybil Antoine and my brothers, Paul, Dave and Ron, for their continued support and encouragement. My parents, Mr. and Mrs. Antoine, have throughout my academic career been unflinching in their support and commitment. I wish to thank them sincerely.

Finally, to my wife Michelle to whom this dissertation is dedicated, I owe a great deal. Without her love, support and understanding, none of this would have been possible.

TABLE OF CONTENTS

		Page
ACKNOWLEDGEMENTS		ii
LIST OF TABLES		vi
ABSTRACT		viii
CHAPTERS		
I	INTRODUCTION	1
	Measures of International Competitiveness	3
	Problem Statement	5
	Objectives	8
	Scope	9
II	LITERATURE REVIEW	11
	Role of Productivity	11
	Empirical Studies	14
	Empirical Studies of Competitiveness and Trade	23
	Theoretical Review	27
	Temporary Equilibrium and Quasi-fixity	30
III	THEORETICAL FRAMEWORK	33
	Introduction	33
	A Measure of International Competitiveness	33
	MIC Development and Specification	44
IV	MODEL SPECIFICATION, ESTIMATION AND EMPIRICAL RESULTS	52
	Introduction	52
	Model Specification	52
	United States Model	54
	Canadian Model	57

Method of Estimation 60
Empirical Results 62
Canadian Model Estimates 63
United States Model Estimates 72
Comparison With Other Studies 83
U.S. Estimates of
Returns to Scale 83
U.S. Estimates of
Input Demand Elasticities 84
U.S. Estimates of
the Elasticity of Supply 85
U.S. Estimates of
Technical Change 86
Canadian Estimates of
Returns to Scale 86
Canadian Estimates of
Input Demand Elasticities 87
Canadian Estimates of
Technical Change 89

V ANALYSIS 91

Trends in Competitiveness 92
MIC and Historical Trends
in Trade and Production 97
Comparison With Other Studies of
U.S-Canadian Agricultural
Competitiveness 107
Sources of Competitiveness 111
Role of Technical Change 117

VI SUMMARY AND CONCLUSION 127

Summary 127
Results 127
Conclusion 132
Suggestions for Future Research 135

APPENDIX DATA USED FOR THE ESTIMATION
OF U.S AND CANADIAN MODELS 138

REFERENCES 147

BIOGRAPHICAL SKETCH 158

LIST OF TABLES

Table		Page
4.1	Parameter Estimates for Translog Variable Cost Model, Canada 1961-1989	64
4.2	Statistics for Test of Hypothesis, Canada	68
4.3	Input Demand Elasticities Canada at Geometric Means, 1961-1989	71
4.4	Allen Elasticities of Substitution, at Geometric Means, Canada, 1961-1989	73
4.5	Returns To Scale, Canada, 1962-1989	73
4.6	Parameter Estimates for Translog Variable Cost Model, United States, 1961-1989	75
4.7	Statistics for Test of Hypothesis, United States	76
4.8	Compensated Output Supply and Input Demand Elasticities United States at Geometric Means, 1961-1989	77
4.9	Allen Elasticities of Substitution, United States, at Geometric Means, 1961-1989	78
4.10	Returns To Scale, United States, 1962-1989	80
4.11	Decomposition of TFP Growth, Canada, 1962-1989	81
4.12	Decomposition of TFP Growth, United States, 1962-1989	82
5.1	Competitive Advantage United States and Canada, 1961-1989	93
5.2	Annual Rates of Change in Value Added Unites States and Canada, 1961-1989	96
5.3	Sources of Increase in Restricted Profits United States and Canada, 1962-1989	112

5.4 Decomposition of TFP Growth,
United States and Canada, 1962-1989 120

5.5 Accounting for Growth in Aggregate Output,
Unites States and Canada, 1962-1989 121

Abstract of Dissertation Presented to the Graduate School
of the University of Florida in Partial Fulfillment of the
Requirements for the Degree of Doctor of Philosophy

MODELLING INTERNATIONAL COMPETITIVENESS:
AN ECONOMETRIC APPROACH

By

Patrick A. Antoine

August 1992

Chairman: Timothy G. Taylor
Major Department: Food and Resource Economics

In the 1980s, international competitiveness emerged as a major concern among countries. Interest in agricultural competitiveness also heightened, due to shrinking export demand and increased pressures to reduce government support to agriculture through international agreements. These occurrences have increased the need for economic models which can account for changes in the pattern of competitiveness. In response, this study developed a model which integrates various determinants of competitiveness and assesses their relative importance for bilateral agricultural competitiveness.

The analysis of competitiveness has generally focused on differences in production costs, exchange rates and technical change between competing industries in a long-run equilibrium context. However, industry receipts and quasi-fixity of some factors of production are also likely to be important determinants of competitiveness. A model for evaluating the

relationships between economies of scale, technical change, exchange rates and factor costs on industry competitiveness, within the context of sub-optimal adjustment by some factors is developed, and the impacts of changes in these factors on bilateral competitiveness examined.

Structural models, consisting of the cost function, share equations and profit-maximizing conditions, along with the influence of demand factors are specified within a partial equilibrium framework. The estimated coefficients were then used in the construction of bilateral competitiveness indices for U.S and Canadian agriculture. The parametric estimates are also used to derive input-demand and product supply elasticities. These elasticities were used to assess model consistency and as explanatory variables in accounting for changes in the bilateral indices.

The results indicate that over the 1962-1971 period, Canada was more competitive than the U.S. However, this competitive position was reversed in the period 1972-1989. The results also suggest that the two most important determinants of changes in the estimated competitiveness index were the relative product price effect and the rate of technological progress.

CHAPTER I
INTRODUCTION

The internationalization of the world economy, fostered by the free movement of capital, technology and traded goods, has resulted in countries becoming more economically interdependent. Trade as the engine of growth in virtually all economies has been enhanced partly by the General Agreement on Tariffs and Trade (GATT), which encourages trade liberalization and integrated markets for goods. Since virtually all economies have become integrated through trade, national policies as they relate to trade can have serious implications for the pattern of trade between countries. The process of internationalization and the attendant integration of capital markets has meant a more rapid transmission of national disturbances resulting from domestic and trade policy distortions into the global economy. Hence, product flows between trading partners will be impacted directly by national government policies, exchange rates, national income and domestic policies. It is within this context that competitiveness assumes greatest importance.

Competitiveness may either be defined in terms of the composition of output or the composition of employment. Four general definitions have emerged in the literature two of which are related to macroeconomics and two to microeconomics. Perhaps the most common definition is the aggregate trade performance definition. The aggregate trade definition holds that a declining trade balance is symptomatic of declining competitiveness. By this definition a country is losing its competitive advantage if its trade

balance is declining relative to that of its trading partners. This is the definition implicit in studies linking the trade balance to competitiveness (Hicks, 1959; Johnson, 1968).

While this definition is related to overall country competitiveness, a second definition relates to the competitiveness between sectors or industries across countries. According to this definition, a sector or industry is competitive if its sectoral trade balance is improving relative to the industry or sector in another country.

According to the third definition, the competitiveness of an industry or sector within a country is declining if its share of the market is declining relative to that of its trading partners. This market-share definition assumes that over time an increase in market share is evidence of increasing competitiveness. This definition has become popular in industry-level studies which compare competitiveness between competing industries in different countries. The productivity definition is the forth definition of competitiveness prevalent in the literature. According to this definition, a country's competitiveness is determined by the relative rate of growth of productivity. By this definition, an industry's competitiveness is enhanced vis-a-vis a competing industry in another country if it experiences relatively higher rates of productivity improvements. McCulloch (1986) argues that, whereas causality between greater productivity gains at the industry level and enhanced competitiveness are automatically assumed, neither result is logically implied.

While not easily amenable to definition, competitiveness in its most sterile sense refers to the ability to win or achieve some goal. In his

seminal writings on competitiveness, Balassa (1962) defined it as the ability to sell under conditions of fixed exchange rates. Subsequently, Islam (1983) redefined competitiveness based on the original definition advanced by Balassa to include changes in costs, prices, or exchange rates. According to Islam, a country's competitiveness may be enhanced relative to that of another country if currency depreciation causes its market share to increase relative to that of its competitor. The commonality between the definitions of Balassa and Islam is that they both view competitiveness in terms of the ability to capture market shares. In sector (e.g. agriculture, manufacturing), it usually refers to the ability to sell profitably both at home and abroad. It is to this latter definition of competitiveness, originally advanced by Balassa and subsequently amended by Islam, to which this study subscribes.

Measures of International Competitiveness.

Measures of international competitiveness are often used as a performance criteria in analyzing sectoral or macroeconomic performance across countries. In addition to quantifiable variables, commonly used measures also encompass qualitative factors such as product specialization, product quality, and the value of after-sales service, among others. While the inability to account for these non-quantifiable though important factors is undoubtedly a drawback for some purposes, it may not be critical if changes in relative competitiveness, rather than absolute levels of competitiveness, are used in analyzing trade trends. To the extent that this is possible, some of the failure to explicitly account for non-quantifiable factors may be mitigated.

Durand and Giorno (1990) contend that ideally, macroeconomic measures of competitiveness should satisfy three basic criteria:

(1) they should cover all commodities exposed to competition;
(2) they should encompass all the markets open to competition; and
(3) they should be constructed from data that are fully comparable internationally.

However, considerable disagreement exists in relation to the credibility of such aggregate measures as suggested by Durand and Giorno (1990) for the measurement of international competitiveness. The basic argument is that while a country may not be competitive according to aggregate measures, such may not necessarily be the case based on individual commodity measures of competitiveness. In addition, on an aggregate sectoral level even in sectors that are highly competitive, it is not expected that all commodities produced within the sector will exhibit the same degree of competitiveness or be competitive at all, for that matter, in relation to commodities produced elsewhere. These arguments are quite valid and do raise questions about the ability of such aggregate measures to correctly measure international competitiveness.

Dissatisfaction with the "conventional approach," as it related to the determination of comparative advantage from an empirical standpoint initiated the search for an alternative explanation of the pattern of trade. In particular, the pre-trade specification of relative prices proved inappropriate for a world replete with trade and other distortions. Vollrath (1991) argued that difficulties also surfaced when attempts were made to deviate from the simplified neoclassical world to incorporate characteristics of the multi-dimensional real world, typified by both inter- and intra-country trade. Consequently, attempts to attain empirical estimates of comparative advantage from observed trade data, in the

presence of market distortions, often proved frustrating due to the inability to surmount some of the associated problems.

It is in light of these difficulties that Balassa and others developed their notions of competitiveness. Implicit in both the definitions of Balassa (1962) and Islam (1983) is the notion of relative (as opposed to absolute) changes in competitiveness as being central to the measurability of international competitiveness. At the macro level, a country's absolute competitiveness can give useful insights into general productivity trends, (i.e., how efficiently a country produces relative to other countries). Relative competitiveness, on the other hand, suggests which country will be a net importer of some commodities and a net exporter of others.

While it is possible to access cross-country competitiveness in a static framework, continuous shifts in relative competitiveness suggest that a framework which accounts for these changes over time (dynamic framework) may be more useful.[1] Morici (1984) argued that it is this dynamic outlook that holds the greatest consequence for structural change and adjustment in the U.S. and Canada.

Problem Statement

It is the intent of this study to develop a general econometric model which will measure multilateral sectoral/industry competitiveness

---

[1]Absolute competitiveness is used in the study to characterize how efficiently a country produces relative to other countries-whether general levels of productivity are higher\lower relative to competitors. Relative competitiveness refers to changes in the structural factors that underscore comparative advantage, as well as to government policies instituted to create or maintain comparative advantage. A country will export commodities in which it has a competitive advantage and import those in which it has a competitive disadvantage.

performance between countries. This will be accomplished using a restricted profit function, in the presence of short-run disequilibrium and nonconstant returns to scale. Interest in international competitiveness in industrialized countries increased in the 1970s amidst unprecedented threats to market shares from Japan and the newly industrialized nations of Taiwan and Korea. In the economic literature, the research agenda took considerably longer to react, and theoretical work on international competitiveness did not begin appearing until the early 1980s. Thompson (1981) reviewed over 300 studies, most of which were in the areas of international trade and agricultural sector modelling, but which in some way related to the concept of competitiveness. Brinkman (1987), however, contends that the various approaches utilized by these studies were inappropriate for assessing competitive performance between countries, since they only dealt with competitiveness in an indirect manner through domestic prices in the specification of supply and demand factors and through transport cost and policy variables. Only recently have attempts to directly assess international competitiveness appeared in the theoretical literature. In many cases though, the sole focus has been on measuring international competitiveness, and in this regard the work of Vollrath (1987) is noteworthy.

A subject of considerable importance, and one in which theoretical progress has been slow, is the examination of the factors that determine or explain competitiveness between countries. This is to some extent understandable, since the lack of a universal definition for competitiveness makes any attempt to attribute competitiveness to certain specific factors elusive at best. Still, the ability to define

international competitiveness as the result of a number of specific causal processes, some quantifiable, others less so, can further advance its understanding. It is still regarded as a 'black-box' by many economists, and remains an area of concern for economic entities that must compete in global markets.

Competitiveness is also widely believed to be the outcome of a number of dynamic forces acting in concert. This belief is partly supported by the view that the global economy is in a constant state of flux. Many believe that any attempt to develop a serious explanation of the factors determining competitiveness must of necessity account for changing international and domestic factors. As an industry loses competitiveness, firms must either shift to another economic endeavor or leave the sector altogether. Any measure of international competitiveness must account for these changes in the global marketplace.

There has been a proliferation of articles which allude to international competitiveness either directly or indirectly. While asserting competitiveness as a critical issue on the national agenda, they do not possess the theoretical rigor or the empirical content through which a determination of the patterns or magnitudes of trade between countries can be achieved.

In sharp contrast to the large number of studies which indirectly address international competitiveness (international or interregional trade models), studies which directly address competitiveness in agriculture are relatively few. Interest in developing an alternative framework for the measurement of international competitiveness is underscored by the associated difficulties with empirical implementation

of the principle of comparative advantage, in conjunction with slow theoretical progress in the development of measures of international competitiveness capable of explicitly accounting for the factors that determine or explain competitiveness between countries.

In developing this alternative framework, it is the intent of this study attempts to develop an empirically estimable model of international competitiveness which will facilitate analysis of both the absolute and relative importance of various determining factors on competitive performance. While the model developed in this study is quite general, it will be applied to competitiveness in agriculture.

Objectives

Many factors influence competitiveness; several of them have already been mentioned in the introduction to the study. Regretably, not all of them can be examined in a study of this nature. Hence, this study will focus on a number of specific factors considered common to the theoretical literature on competitiveness.

The first objective of the study is to build on previous research to develop a multilateral theoretical model of international competitiveness in order to

(1) measure the impact of productivity, economies of scale, and technological differences between countries, as well as wage, price, exchange rates and national agricultural and trade policies instituted by individual governments on a measure of international competitiveness; and

(2) examine the relationship between these factors and the relative importance of each to changes in the measure of international competitiveness.

The second major objective is to construct an empirical model based on production theory which explicitly accounts for differences in the

structure of production between countries. The specific objectives of the empirical analysis are to

(1) test the propositions arising out of the theoretical analysis with respect to the structure of aggregate agricultural production in Canada and the United States;

(2) compute empirical estimates of the model using data for the U.S. and Canada from 1961-1989;

(3) utilize the relevant parameters as the basis for inquiry proposed in goal (1) above, and the first objective stated; and

(4) provide insights into the policy implications for the agricultural sectors in both the U.S. and Canada, based on the results of the model.

Scope

This study will examine international competitiveness in agriculture between the U.S. and Canada from 1961 to 1989. Warley (1977) argues that no sector better demonstrates the deepening interdependence of the world economy than agriculture. The implication of this 'deepening,' as Warley calls it, for the U.S. and Canada has been increased competition for markets, owing to the similar nature of the agricultural commodities produced and exported by both countries. In addition, Warley argues that the strength of the North American economy and, in particular, its ability to influence world economic events, is highly dependent on the performance of the agricultural sectors in the world economy. Consequently, the issue of international competitiveness in agriculture between the U.S. and Canada seems particularly amenable to analysis via the theoretical model proposed in this study.

Achieving and maintaining competitiveness depends on a gamut of both demand and supply factors which will determine which commodities will be imported or exported. In the short-run, however, a country's ability to

compete will ultimately be determined by the ability to offer similar commodities at more competitive prices than other countries. In the case of similar products, though, a country's demand would most likely be invariant to the source of supply. National government policies will also affect the competitiveness of a country's exports, along with the explanations of resource costs and resource endowments advanced by conventional trade theory.

Empirical investigations of these factors as well as the forces, that determine both absolute and relative competitiveness, are critical to the understanding of competitiveness in the short-run. Empirical measures of international competitiveness should therefore account for the influences of real factors (those determining productivity), monetary factors (wages, prices and exchange rates), and structural factors, the most important of which are supply conditions, along with the effects of national government policy.

CHAPTER II
LITERATURE REVIEW

In this section a review of studies deemed of significance to the determination of international competitiveness is undertaken. In addition, the results of a number of other empirical studies linking competitiveness to both comparative advantage and productivity are presented. Finally, a review of the theoretical foundations on which a number of industry-level studies have been based is pursued and the results of these studies discussed.

Role of Productivity

A great deal of attention has been given to the role of productivity in determining competitiveness. However, Porter (1990) argues that to seek to explain competitiveness at the national level is to answer the wrong question. He contends that what must be understood, instead, are the determinants of productivity and the rate of productivity growth. Sudit (1984) developed a framework for analyzing the role of comparative productivity accounting in export decisions at the firm level. Specifically, the model relates export decisions to productivity ratios, input prices, scale effects, demand patterns and exchange rates. Firm profitability in foreign markets is used as a proxy for competitiveness of exports. The results suggest that with homogeneous products and in the absence of market distortions, export profitability can be determined exclusively from a knowledge of the relative cost of production between countries. However, where there are differentiated products, imperfect

competition or significant selling costs, the firm must be mindful of the price elasticity of demand for its products in foreign markets if it is to retain its current competitive position or enhance its position in the future. In this setting, the relative costs of countries will indirectly affect demand so long as the goods are close substitutes. The role of productivity in competitiveness is crucial; not only is it a source of profitability, but in the long-run, it also provides incentives for increases in the market share of the firm with the productivity advantage. Relative productivity advantages also provide time for adjustment to adverse relative changes in more volatile variables (exchange rates, prices, etc.) without declining competitiveness (measured by market shares). Studies by Kendrick (1977) and Crandall (1981) on the iron and steel industry reveal both the strength and weaknesses of attempts at cross-country comparisons which utilize partial productivity measures, such as the one employed by Sudit (1984). Data for the period 1964-73 show that the increases in the relative labor productivity for Japan's steel industry was matched almost equally by exchange-rate appreciation, hence no associated increases in the comparative advantage were attained. However, the omission of the role of other factors such as capital made the analysis, at best, incomplete. Significant advances in relative capital productivity between the U.S. and Japan gave Japan a significant comparative advantage in steel products. So, though partial productivity measures are useful, they must be interpreted carefully since they do not present the entire picture.

The notion of total factor productivity (TFP) has now become the standard measure of efficient factor utilization (Langham and Ahmad,

1983), so much so that the partial measures are hardly used as a measure of relative industry competitiveness. It is thus crucial to understand the meaning of TFP. It is a residual measure of the economic and technical efficiency with which inputs are converted into outputs. An increase in the output-input ratio (TFP) is indicative of increased overall economic welfare. This arises either by producing given output with less inputs or by producing more output with a given amount of input. So the growth of economies, sectors, and industries can all be determined by the rate of growth of their output and by the rate of TFP growth. In addition, increasing TFP growth is likely to be a primary means of raising per capita income and output. Other benefits of increasing TFP growth are suggested by Kendrick (1977), such as cheaper food, which he argues mitigates inflation, and an increase in the competitiveness of domestic production.

It is also prudent to examine the relationship between productivity and comparative advantage, since among other factors long-term growth or economic progress involve exploiting the opportunities of changing comparative advantage. Classical (Ricardian) trade theory holds that comparative advantage based on relative productivity differentials determines international specialization. Accordingly, output can be increased if a country specializes in the production of goods in which it has a comparative advantage. The assertion that productivity advances are crucial to classical trade theory is predicated on the grounds that given a fixed resource endowment, an increase in output can occur only if productivity increases. As such classical trade theory is based on the assumption that relative productivity differentials will exist between

countries. It is these relative productivity differentials that determine the country's absolute or comparative advantage.

Empirical Studies

To put the concept of competitiveness into perspective it is helpful to mention some of the salient measures of competitiveness cum comparative advantage. Conventional measures include various constructs of the terms of trade and balance of trade accounts (McCulloch, 1986). These measures reflect expost statements of sectoral or national trade performance, but they provide little information on the potential for continued profitability of trade flows or the potential for growth in the patterns of trade of specific commodities.

Balassa (1965) developed the concept of Revealed Comparative Advantage (RCA) as a more refined measure of inter-country comparisons of competitiveness (market shares). Specifically, the author test three variations of Revealed Comparative Advantage as measures of a country's market share:

(1) domestic export share to world market share,

(2) relative sectoral trade balances shares, and

(3) commodity export share as ratios to world market share.

Vollrath (1987) built on RCA, by redefining the measure as the difference between revealed competitive supply and revealed competitive demand.

Perhaps the most widely applied measure of economic performance and international competitiveness arising in economic literature is the Domestic Resource Cost (DRC) criterion, which is a single period, social cost-benefit indicator that gives the domestic factor cost evaluated at shadow prices of generating a unit of value added at international prices.

Early definitions and applications of the DRC criterion include Kruger (1966) and Bruno (1967). More recent expositions appear in Srinivasan and Bhagwati (1978) and Islam (1984). Activities with the lowest DRC ratios are normally assumed to exhibit the greatest potential for expansion of exports or the greatest potential for efficient import substitution (Nishimizu and Page, 1986).

DRC as a measure of comparative advantage hinges critically on whether production costs are appropriately computed in terms of domestic primary factor content as opposed to the opportunity cost of foreign exchange (Lucas, 1981). The total DRC (TDRC), popularized by Bruno (1967) and Kruger (1966), measures the cost of intermediate goods currently produced domestically by their primary factor content. The direct DRC (DDRC), on the contrary, evaluates all intermediates at world prices converted at the shadow price of foreign exchange (such an approach is reflected in the work of Balassa and Schydlowsky, 1968).

Lucas (1981) tested the proposition advanced by Srinivasan and Bhagwati (1978) that the DDRC and TDRC measures were equal when appropriately measured (evaluated at first-best shadow prices and costs). In addition to confirming the Balassa-Schydlowsky proposition, Lucas proved that the two approaches were equivalent only when no prior restrictions on trade existed, a circumstance he argued was unlikely to occur in reality. He also defined a generalized measure of DRC (which he termed the optimal DRC (ODRC) from a linear programming production model with multiple commodities and fewer resources. The ODRC was defined in terms of a sourcing matrix, which measured the effect of intermediate goods cost alternatively by primary factor content or in terms of foreign

exchange. His findings suggested that the two measures of DRC also coincided with this 'optimal' DRC when no trade distortions existed. Lucas' work showed that once restrictions on trade are permitted, both the DDRC and the TDRC can generate incorrect rankings of commodities in terms of the comparative advantage criterion. He further contended that the direction of error was unknown, since world prices could either over or understate 'true worth'. Lucas concludes by arguing for the:

> adoption of a direct and not a total DRC criterion when the small country assumption holds. If sourcing is restricted, the direct DRC may well be inappropriate and the correct measure is indeed one embracing indirect inputs but not typically the total DRC. (Lucas, 1981, p. 24)

The distinctions between the DDRC and TDRC measures are important, since they impinge on the very credibility of the variants of the DRC measure to reflect comparative advantage. The work of Lucas suggests that both the DDRC and the TDRC may be inappropriate measures of comparative advantage. Further, it appears that, while use of the DDRC may be justified on certain grounds, the same cannot be said of the TDRC.

The TDRC measure is defined as the ratio of direct plus indirect value added at the domestic prices to value added at the international prices, taking into account the direct as well as the indirect import requirements. On the other hand, the DDRC includes in the numerator only the direct value added and only the direct inputs at the world price in the denominator. This distinction turns out to be more important than it would appear at first. For instance, if an activity uses domestically produced inputs, produced by another activity under protection, the former activity will not be accounted for by TDRC, but will be reflected in the DDRC measure. This occurs because the protection artificially inflates the

domestic value added component of the inefficient input producing activity, which is included in the numerator of the TDRC. As suggested by Lucas, in this case the DDRC should be utilized, and each transformation activity left to stand on its own. This is even more pertinent to situations where interest may lie in prescribing or analyzing trade policies, in which case it does not seem reasonable to constrain the sourcing of inputs and to vertically integrate industries that could well benefit from trade in intermediate products (Azizul, 1980).

DRC cannot provide an understanding of the historical forces which gave rise to the current pattern of comparative advantage. The measure is static and says very little of dynamic factors which may influence competitive advantage. In addition, studies utilizing the DRC framework have made few attempts to measure changing DRC over time.

Tange (1983) developed an insightful model of cost competitiveness between Japan and the U.S. In his model, the unit cost of an industry was derived on the basis of the Cobb-Douglas production function. The rate of change in unit cost is determined by the rate of technological progress, factor price changes and output growth. The model shows that the relative cost competitiveness between two countries, as measured by the rate of change of unit cost, determines the differences in exports. Technological progress is assumed to affect export performance through its effect on costs. As such, the model analyzes the impact of inter-country differences in the estimated rate of technical progress on cost competitiveness and exports. Specifically, the hypotheses may be stated as follows: the country's industry with the higher rate of technological progress, relative to the other country, will exhibit a slower rate of change in

unit cost, which results in a higher rate of export growth. Mathematically this may be written as

$$\frac{\dot{AC}}{AC} = \frac{\alpha \dot{w}}{Rw} + \frac{\beta \dot{r}}{Rr} + \frac{(1-R)\dot{V}}{RV} - \frac{1}{R}\alpha \qquad (2.1)$$

where V is valued added and $R = \alpha + \beta$, α, β, w is wage rate and r is the rate of return on capital.

The equation states that the rate of change in unit cost is determined by the rates of percentage change in factor prices, value added, and in the rate of technological progress, respectively. Tange's findings suggest that inter-country differences in manufacturing export growth were negatively related to inter-country differences in unit cost changes. Japanese industries had a higher rate of technological change, slower growth in unit cost and higher rates of export growth than their United States counterparts. As such the study concluded that U.S. firms were less competitive than Japanese firms in manufacturing. Several other studies focusing on inter-country comparisons between the United Kingdom and the Netherlands, the United Kingdom, France and Germany and the Common Market. McGeehan (1968) also concluded that the impact of productivity induced cost reductions have been significant in increasing the competitive positions of various countries.

Several studies have tried to account for the impact of price and non-price factors on international competitiveness (Junz and Romberg, 1964). The results of these studies are inconclusive as to whether there is a definite causal relationship between changes in supply conditions, export performance and changes in comparative export prices. McGeehan (1968) argued that price is only a proximate measure, and that

competitiveness must also encompass considerations of costs and their determinants -- productivity and product prices.

Notwithstanding the numerous measures of international competitiveness which exist, it appears one of the most popular is based on the growth in relative unit labor cost (RULC). In terms of the RULC framework, if unit labor costs grow more in one country than in another, then the country with more rapid growth will suffer reduced market share at home and abroad and slower economic growth coupled with increased unemployment. However, several studies including Featherstone (1977) and Kellerman (1983) have shown that the effect of growing relative cost or prices on export and market shares seems to be weak and rather perverse. This led to what is often referred to as the 'Kaldor paradox' which suggests that the view of growth in unit labor costs determining international competitiveness is far too simplistic. The theory of the detrimental effects of increases in relative unit labor cost on market shares and growth is based on the following assumptions:

(1) that imperfect competition or disequilibrium exists, and

(2) that the Marshall-Lerner conditions are strictly satisfied.[1]

Thirlwall (1979) argues that the balance of payments equilibrium growth rate may be written algebraically as

[1] The Marshall-Lerner conditions states that the sum of the elasticities of demand for a country's exports and of its demand for imports has to be greater than unity for a devaluation to have a positive effect on a country's trade balance. If the sum of the elasticities are less than unity, a country can improve its balance of trade by revaluation.

$$Y_{Bt} = \frac{(1+\eta+\Psi)(P_{dt}-P_{ft}-e_t)+\epsilon(z_t)}{\Pi} \qquad (2.2)$$

where Ψ is the own-price elasticity of demand for imports ($\Psi < 0$); η is the own-price elasticity of demand for exports ($\eta < 0$); ϵ is the income elasticity of demand for exports ($\epsilon < 0$); P_{dt} and P_{ft} are the price of exports and the price of goods competitive with exports respectively; Π the income elasticity of demand for imports, e_t the rate of change of the exchange rate variable, and z_t the level of income. The equation states that inflation at home acts to lower the balance of payments equilibrium growth rate if the sum of the own-price elasticity of demand for exports and the cross-price elasticity of demand for imports is greater than 1. Conversely inflation will improve a country's balance of payments equilibrium growth rate if the sum of the own-price elasticity of demand for imports and the cross-price elasticity of demand for exports is greater than 1 in absolute value. Consequently, devaluation will improve the balance of payments equilibrium growth rate if the Marshall-Learner conditions are met. Thirlwall (1979) further assumes that in the long run, relative prices will be roughly constant, so that the first term can be neglected. On this assumption the equation above reduces to

$$Y_{Bt} = \frac{X_{Bt}}{\Pi} \qquad (2.3)$$

where X_{Bt} represents the growth rate of exports, so that economic growth between countries is determined exclusively by differences in income elasticities of exports and imports. McGregor and Swales (1985) and Thirlwall (1986) contend that the assumption of constant long run relative prices is a strong one and should be subject to empirical testing. This

issue aside, however, it appears Thirlwall's conclusion that the equation gives accurate predictions on the differences in growth rates between countries may be flawed. McGregor and Swales (1986) and Boggio and Tirelli (1989) contend that the view of those adhering to the pivotal and sometimes exclusive role of income elasticity differentials in the determination of differential economic growth among countries is flawed since they only capture price competitiveness, the notion of international competitiveness being in fact much broader. In addition, the authors argue that contrary to the practice in several models, the explanation of exchange rates changes should be couched in terms of international price differences instead of relative price changes. This leads to the acceptance of the view and subsequent construction of a model which reinstates cost competitiveness as a key determinant of differences in international growth rates.

Fagerberg (1988) developed a model of international competitiveness in which growth and market shares are related to the ability to compete in technology, the ability to compete in price and the ability to compete in delivery. The results indicate that factors related to technology and capacity are important for long run differences across countries in growth of market shares and GDP, while cost competitiveness was found to play a more limited role than previous studies suggest. The results by Fagerberg (1988) lends support to the "Kaldor Paradox."

Paul (1970) developed a model which sought to explain export competitiveness based on cost and demand influences. The study's results are rather tentative, but they suggest that while differences in productivity between competing countries exist, they do not appear large

enough to explain a significant proportion of the unexplained differential in price. The study also suggests that both exports and demand factors were significant in explaining competitiveness. However, since productivity depends on both price and non-price factors, it is doubtful whether analysis based solely on price can correctly capture the role productivity plays in international competition (Nelson, 1981). Still others (e.g. Pack, 1984) have shown that the role of technical change on productivity is large and significant. In a study of the textile industry in the Philippines, the author concluded that the high costs of production were due to both inappropriate technology choices and low productivity in the use of the chosen technology. The author also reasoned that the low productivity was due to the short production runs.

Work on productivity and international competitiveness has also progressed in another direction. Bernhardt (1981) argued that small markets may induce low relative productivity since they inhibit both external and internal scale economies. Interestingly, the author argued that internal scale economies may be lost when plant sizes are small relative to the efficient size, or when there is excessive diversification or integration, an issue which currently lies at the core of diversification strategy programs for Lesser Developed Countries. The inability to attain external economies would more likely be reflected in high production costs due to excessive integration or diversification, or in high transaction and inventory costs. This has a direct bearing on international competitiveness since either inappropriate plant size or excessive diversification will make it difficult to obtain competitively

priced supplies, higher transaction and inventory costs and possibly higher prices (Scherer, 1987).

Most cross-country international comparisons of productivity surveyed by Kravis (1976) show a positive relationship between relative productivity and relative market size (the presence of economies of scale). Still others, such as Shen (1970) extend the relationship between market size and competitiveness in other directions.[2]

He identified certain persistent but imperfect competitive advantages which fall into three groups: product differentiation, price advantage, and productivity advantages. The growth of plants is positively related to technology, where advantages in technology are assumed transitory.

Empirical Studies of Competitiveness and Trade

MacDougall (1951) compared relative export volumes and relative productivity differences for American and British manufactured exports. He concluded that differences in export shares were better explained by differences in unit labor costs than by productivity. Evidently the same controversies developed in the international trade circles as in the production economics field. Balassa (1963) continuing the work of McDougall, found that a linear relationship between productivity and export ratios existed. He also found that the relationship between export shares and wages was not uni-directional, so that while lower wages could lead to higher export shares, higher export shares could also induce higher wages. In addition, Balassa argued that the role of transport

[2] Little has, nor will be, said on the sources of productivity growth. While a topic of heightened academic interest, various studies have already addressed this issue, listing many and varied factors as inducing productivity growth (see Nelson, 1981).

costs, along with noneconomic factors, were crucial in explaining the competitive position of countries.[3]

Nishimizu and Page (1986) decomposed DRC into three distinct elements arising from changes in international prices, total factor productivity and changes in production techniques. This provided a means of understanding the sources of changes in measured comparative advantage. The study found that for the industrial sector of Thailand, the impact of changes in factor proportions was small, while total factor productivity changes were the major influence on international competitiveness. The impact of changes in production techniques, on the other hand, was found to be small. The results of the study are consistent with the implications of the literature on import-substitution and export-led growth, which argues that endeavors geared to exports or import substitution receiving little protection generally show superior TFP change and improvements in international competitiveness, over those which produce protected or non-competing import substitutes (Kruger et al., 1982). Others (Stern and Maskus, 1981; Kilpatrick and Miller, 1978) have also found the impact of productivity to be important in determining export competitiveness.

Empirical studies have also proceeded in another direction. Work on inter-industry trade (IIT), i.e, the simultaneous export and imports of the same statistical product group, has been carried out based on product differentiation (Lancaster, 1980; Krugman, 1979, 1981; Helpman, 1981). Lundberg (1988) developed an IIT model in which factor proportion

---

[3]Bhagwati (1964) contended that the propositions of Balassa and MacDougall represented a departure from the Ricardian price-trade assumption. He, however, concluded that despite the difficulties with the hypotheses, the empirical verifications were "remarkably successful." (p. 24).

variables were used as indicators of comparative costs in production. The model was rationalized on the grounds that international differences in costs of production affected the relative size of the inter- and intra-industry trade, and thus the share of IIT in total trade. The larger the difference in production costs and prices between countries producing in the same industry, the more inter-industry specialization would be expected, and the smaller would be the share of intra-industry trade in that product group. In the model by Lundberg, the market share of domestic production and imports and hence, the extent of IIT, depended on the elasticity of substitution, which reflects the degree of product differentiation. It is possible in the context of the model, to assume that relative productivity differences in the countries generated a divergence of factor prices for inputs between them. The key feature of the model is that with perfect competition and homogeneous products, each group will either be exported, imported or will be non-traded, so there is no inter industry trade; however, if the product homogeneity assumption is relaxed then both inter-industry and intra-industry trade will exist.

Krugman (1987) presented a model in which comparative advantage, evolved over time through learning-by-doing. The approach is predicated on the grounds that there are dynamic economies of scale in which cumulative past output determines current productivity. Krugmans' model has the following key features: resource productivity in each country in each industry depends on an index of cumulative experience.

$$A_i = k_i(t)^{\varepsilon}, \quad a_i = k_i(t)^{\varepsilon}, \quad 0<\varepsilon<1. \tag{2.4}$$

where K_i and A_i represents the cumulative index of experience and the measure of productivity in the home country, and a_i and k_i the cumulative

index of experience and the measure of productivity in the foreign country. Both domestic and foreign production are assumed to enter the index of experience.

$$K_i(t) = \int_{-\infty}^{t} [x_i(z) + \delta x_i(z)]\, dz. \tag{2.5}$$

$$K_i(t) = \int_{-\infty}^{t} [\delta x_i(z) + x_i(z)]\, dz. \quad 0 \leq \delta \leq 1 \tag{2.6}$$

where δ is a measure of the institutionalization of learning. In the model, whatever market conditions the home country starts with will be preserved over time, as will relative wage rates. At any point in time the model is Ricardian in character, so it becomes possible to rank tradeable industries according to their relative productivity $A_i(t)/a_i(t)$.

One critical conclusion of the analysis is that, notwithstanding the possibility of long-run protection giving rise to changes in relative productivity growth (which in turn may generate cost advantages for the home country), high-wage small countries may find that the extra productivity is not sufficient to provide a cost advantage. This is important from a number of standpoints: it not only argues the role of dynamic economies of scale in international competitiveness and establishes the role of productivity in determining international specialization but it also establishes conditions for the preservation of competitiveness in industries between countries over time.

It is apparent from the foregoing review that there is a clear association between productivity and international competitiveness. Yet it is also apparent that other factors not related to efficient resource

utilization also impact the ability to compete internationally. While it is not always possible to quantitatively assess all of these factors, progress in theoretical modelling, particularly that which is geared to analyzing the impacts of various influences on international competitiveness, will depend on the recognition of these factors and the significance of their effects.

A look at the decline in British export shares serves to highlight the importance of this factor. It is argued that the decline in British exports in the sterling currency area was due to the ending of quota restrictions discriminating in its favor. The British advantage was attained at the expense of the U.S. and Japan. However, following the relaxation of restrictions these two countries made serious inroads into the sterling currency area markets, eroding the competitive hegemony of the British, once considered so secure. Empirical work in areas relating to productivity and international competitiveness would appear to be particularly timely.

Theoretical Review

Several approaches to the measurement of international competitiveness have been highlighted in the previous section. The approaches emphasize the importance of demand and supply interactions and their influence on price determination. In competitive markets with trade in similar products, several authors including Mansfield (1982), Tange (1983) and Sudit (1984) have stressed the relative importance of supply and cost conditions in the analysis of export competitiveness. The focus of the present study is therefore on the factors that cause/inhibit competitiveness in the agricultural sector. The theoretical basis for

research in this area is rooted in the literature on duality, popularized by Diewert (1974) and Fuss and McFadden (1978) among others. Gorman (1968) defines duality as being associated with the choice of the independent variable in terms of which one defines a theory. Chambers (1988) argued that by 1980 economists had come to realize that the entire neoclassical theory of cost could be cast entirely in terms of the cost function. More succinctly, McFadden and Fuss used the term "sufficient statistic" in relation to the cost function's ability to adequately characterize production inter-relationships.

In a manner analogous to the development of the cost function, Hotelling (1932) introduced the profit function, which provides an alternative way of describing a decreasing returns technology. Others (e.g., Samuelson, 1947) have contributed to the theoretical conceptualization of the profit function; however it was McFadden (1978) who explicitly developed the dual relationships between the production function and the profit function. The regularity conditions for the profit function are stated in Chambers (1988) and McFadden (1978). Once the profit function satisfies the regularity conditions, Hotelling's Lemma can be applied to derive systems of variable output, supply and input demand functions, in a manner completely analogous to the derivation of the cost minimizing input demand functions attained via Shephard's Lemma for the cost function.

While the application of the dual approach through the cost function and profit function has been prevalent in the economic literature, relatively few attempts have been made to use the dual approach to measure cross-country competitiveness. Although the application of the value-added

function has become common-place in international trade (an application suggested by Diewert (1978) and Bruno (1978), among others), it was not until the work of Jorgenson and Nishimizu (1978) that an explicit parametric model of bilateral performance between countries was developed.

The methodology used in the Jorgenson and Nishimizu (JN) study was developed by Christensen and Jorgenson (1969), who initially applied the model to the measurement of real capital input in the United States. The methodology was later implemented in a study of macroeconomic performance in Japan by Ezaki and Jorgenson (1973). The JN study characterized technology by constant returns to scale and utilized a transcendental production function to analyze differences in the pattern of production between Japan and the United States. This approach has been widely used in subsequent studies, such as those of Conrad and Unger (1989), Conrad (1989) and Berndt and Hesse (1986).

In the JN study, differences between countries were represented by a dummy variable entered directly into the production function. The difference in any variable between two countries, V_D, is determined as the logarithmic difference in that variable between countries, holding all other variables constant. Hence, the difference in technology between two countries may be expressed as

$$V_D = \frac{\partial \ln Y}{\partial D}(K, L, D, T) \tag{2.8}$$

where K, L, D, and T, represent the levels of capital, labor, the discrete dummy, and time as a proxy of disembodied technical change, respectively.

Most studies of international competitiveness using the dual approach have been applied to manufacturing industries. Aizcorbe et al.

(1987) utilized a multi-product cost function to analyze aggregate time series data for automobile production between the U.S. and Japan for the years 1955-83. The theoretical foundation for the study was established in an earlier study by Friedlaender et al. (1983), in which the multi-product cost function was used. Unlike previous studies which assumed that the technology could be represented by a single homogeneous output (e.g., White, 1971 and Toder, 1978), the study by Friedlaender et al. (1983) assumed that manufacturers produced several types of output.

Both the index number approach and the econometric approach through the dual cost function were employed by Conrad (1989) in accounting for cost and productivity gaps in U.S., Japanese and German manufacturing firms. The Conrad study was based on work by Diewert (1976) and Lau (1979) on the economic theory of index numbers. By appealing to the theoretical relationships between aggregator functions and index numbers, Conrad (1986) assessed differences in cost efficiency between countries using the Tornqvist index, which is exact for a homogeneous translog function. The advantage to measuring differences in productivity using index numbers is that it obviates the need to explicitly specify a production function. The theoretical linkage between index numbers and the underlying technology was also exploited in developing an econometric framework for explaining the sources of changes in productivity gaps.

Temporary Equilibrium and Quasi-fixity.

Berndt and Fuss (1986) define temporary equilibrium as a phenomenon which occurs when unexpected demand shocks lead to under- or over utilization of capacity, or when sudden changes in factor prices result in short-run relative factor usage which is non sustainable in the long-run.

The thesis advanced by Berndt and Fuss is that in a static expectations framework for a firm producing output with a single variable and a single quasi-fixed factor, whenever actual output Y exceeds capacity output Y_o, the capacity utilization rate is greater than one, and the shadow rental price of capital z_k exceeds the market rental price of capital, P_k. More succinctly, if $u = Y/Y_o$ is assumed to be the capacity utilization rate, and $q_k = z_k/P_k$ the ratio of z_k to P_k, when u is greater (less) than one, q_k is also greater (less) than one. On the other hand, when $Y = Y_o$, $u = q_k$, and temporary equilibrium no longer exists. The importance of this in measuring total factor productivity growth is that the traditional measure which assumes that the firm is operating under conditions of long-run equilibrium (u=1) misstates the true total factor productivity growth if the firm is at some capacity level of utilization other than that consistent with long-run equilibrium.

Building on this, Hulten (1986) showed that with year to year fluctuations in capacity utilization, the growth rate of real short-run average costs could be decomposed into two effects: the growth rate in multi-factor productivity and the capacity utilization rate. One important result from the Hulten paper is that,

$$\frac{\dot{\sigma}^*}{\sigma^*} = \frac{-\dot{A}^*}{A^*} + \theta\left[\frac{\dot{Q}}{Q} - \frac{\dot{A}^*}{A^*} - \frac{\dot{K}}{K}\right] \qquad (2.10)$$

where θ is a surrogate for the capacity utilization parameter; σ is the actual real unit cost of output Q. $\dot{A}^*/A$ is the "true" multi-factor productivity measure and K is the flow of capital services.

The equation states that the change in real short-term average cost can be decomposed into two terms: the percentage change in productivity

and the percentage change in the efficiency adjusted output-capital ratio weighted by the difference between revenue and costs. The second result of the paper is that the true measure of productivity ($\dot{A}^*/A^*$) and the measure ($\dot{A}^F/A^F$) attained by incorrectly assuming the firm to be in long-run equilibrium, differs by the Berndt-Fuss capacity utilization term, i.e.,

$$\frac{\dot{A}^*}{A^*} = \frac{\dot{A}^F}{A^F} + \theta\left[\frac{\dot{Q}}{Q} - \frac{\dot{A}^*}{A^*} - \frac{\dot{K}}{K}\right] \tag{2.11}$$

where 2

$\theta\left[\frac{\dot{Q}}{Q} - \frac{\dot{A}^*}{A^*} - \frac{\dot{K}}{K}\right]$ represents the Berndt-Fuss capacity utilization measure.

While the contributions of Berndt and Fuss and Hulten were couched along the lines of the traditional index number approach, Morrison (1986) developed an approach which lends itself to econometric estimation. The approach suggested in the Morrison paper is a dynamic optimization model based on adjustment costs for the quasi-fixed inputs. The theoretical rationale for the approach is identical to that of Berndt-Fuss and Hulten. The Morrison paper develops an output and a cost measure of overall efficiency and shows that both coincide under the assumption of constant returns to scale. Finally, Morrison used the cost capacity utilization measure to link the short-run and long-run productivity measures which are adjusted for static expectations and nonconstant returns to scale.

CHAPTER III
THEORETICAL FRAMEWORK

Introduction

This chapter presents an alternative framework for the measurement of international competitiveness. It attempts to generalize the Nishimuzu and Page model in regard to returns to scale and explicitly incorporates optimizing behavior on the part of producing agents. Specifically, a measure of international competitiveness is developed based on optimizing behavior by economic agents as characterized by a restricted profit function with nonconstant returns to scale.

The measure developed accounts for quasi-fixity of some factors of production. Quasi-fixity dictates that agricultural producing industries be modelled as producing a stream of output utilizing both quasi-fixed and variable factors. Previously alluded to was the concept of 'temporary equilibrium' as characterizing the optimizing behavior of producers in such industries. In addition, the Measure of International Competitiveness (MIC) framework is developed in a manner amenable to empirical testing and verification via either econometric or index-number procedures.

A Measure of International Competitiveness (MIC)

Under the assumption of given technology and prices across firms and short-run profit maximization, producer behavior may be represented by a restricted profit function defined by:

$$\pi(p;w) = \max_{x} \{p.y_0 - w.x \mid x \in V_{(\phi)} y_0\} \qquad (3.1)$$

where π is restricted profits, p is a vector of output prices, $V_{(\phi)}$ represents the input requirement set, w the vector of input prices, y_0 the level of fixed output i.e, $y = y_0$ and x the vector of inputs.

The proofs and properties of the restricted profit function (RPF), are given by McFadden (1978). The properties are that the RPF is a continuous twice differentiable convex function, strictly increasing in p, strictly decreasing in w, closed in p and w in the nonnegative orthant, finite for all finite p and w, positive, and homogeneous of degree one in p and w.

Bruno (1978) extended the usefulness of the restricted profit function for empirical analysis by proving its equivalence to the more familiar value added concept. Bruno defined nominal value added as gross returns minus total costs of intermediate inputs. However, since the nominal value added function varied with changes in output or input prices, modifications were needed for the purpose of measuring economic changes. Consequently, Bruno presented two modifications of the value added (VA) concept, one based on deflation of the VA function by a single output price (SVA); the other based on measurement of VA in base-year input and output prices (DVA). While Bruno showed that both modifications were valid under different assumptions about the structure of production, he argued that the DVA modification had more practical application in the measurement of productivity and in the analysis of the effects of tariff structures on resource allocation.

A well known result in production economics is the relationship between the profit and cost function. Lau (1976) showed that the profit

function will accommodate the cost function with the level of output fixed. Specifically, given the assumption of fixed output, profits will be maximized only if the cost of producing y_0 units of output is minimized, i.e, if $\pi(p,w)\big|_{y=y_0} = -C(y_0,w)$.

The relevance of this is that it proves that the conclusions of the comparative advantage model are completely attainable via an alternative characterization of the technology - via the profit function. In a two country framework where comparative advantage is determined on the basis of relative costs this suggests that commodities will only be produced if profits in the home country exceed profits in the foreign country. This is in accordance with the findings of Bhagwati (1964), who states that "what the Ricardian model reflects is that the profit motive will direct the pattern of trade." (p. 9).

Based on the proof by Lau (1976), the model of international competitiveness developed below assumes that economic agents will produce and export commodities based primarily on the profit motive. The concept of international competitiveness differs from the conventional theory of comparative advantage in at least three respects. Firstly, the profit functions are specified in post-trade prices as opposed to the pre-trade prices used in the comparative advantage specification. Second, relative to the theory of comparative advantage, the concept of competitiveness incorporates distortions and deviations from the free trade assumption. Finally, the comparative advantage theory is a general equilibrium construct, while the competitiveness framework developed here is cast entirely in a partial equilibrium mould.

The Measure of International Competitiveness (MIC) between country i and country j is thus defined as

$$MIC^{t}_{i,j} = \frac{\pi_{i,t}/\hat{z}_{i,t}}{\pi_{j,t}/\hat{z}_{j,t}}, \tag{3.2}$$

where $\hat{z}_{i,t}$ and $\hat{z}_{j,t}$ represents the level of quasi-fixed input in country i and country j, respectively. Equation (3.2) implies that the ratio of restricted profits per unit of quasi-fixed resource, measured in the same currency, between two countries producing homogeneous products with similar inputs, constitutes the basis for the international competitiveness measure (MIC).[1]

Restricted profits are a residual measure capturing returns to the quasi-fixed or primary factors, constrained by the cost of adjustment from optimally adjusting instantaneously to their long-run level. Defined in this manner the measure is somewhat similar to the Nishimizu-Page (NP) DRC measure. To see this, assume that country 1 and country 2 produce traded output (Y), using both variable (traded) and quasi-fixed (non-traded) factors of production. Let non-traded labor and capital inputs be represented by L and K respectively and variable inputs by X. P_y and P_x represent the output price and the price of traded inputs respectively, while $\hat{w}$ and $\hat{r}$ represents the shadow prices of non-traded labor and capital respectively. The ratio of DRC measures between county 1 and country 2 is written as

[1]It is assumed that both country's prices are measured in the same currency, achieved by conversion through the nominal exchange rate.

$$D_{1,2} = \frac{\left[\frac{P_y^1 Y^1 - P_x^1 X^1}{\bar{w}^1 l^1 + \bar{r}^1 k^1}\right]}{\left[\frac{P_y^2 Y^2 - P_x^2 X^2}{\bar{w}^2 l^2 + \bar{r}^2 k^2}\right]} \tag{3.3}$$

If it is assumed that there are no external economies, market distortions, transport cost and international factor movements, the market price of primary factors will equal their opportunity cost or shadow price. If for some reason one of these assumptions does not hold, the market price and shadow price of primary factors will diverge. The market price of the other factors are assumed to be equal to their shadow price, due primarily to the ability of these factors to adjust optimally to short-run fluctuations.

In general factor-price equalization for traded inputs will not exist even when trade occurs between countries. This is because market distortions generally differ across countries. In this framework, however, since none of the factor prices are jointly determined between countries (such as in a general equilibrium framework), the lack of factor price equalization is not an important consideration.

Equation (3.3) implies that if per unit returns to quasi-fixed factors in country 1 exceed per unit returns in country 2 the ratio of DRC's, ($D_{1,2}$) will be greater than one; when per unit returns in country 2 exceeds per unit returns in country 1, $D_{1,2}$ will be less than one. Only when per unit returns between country 1 and country 2 are equal is $D_{1,2}$ equal to one.

The ratio of DRC's in equation (3.3) therefore constitutes a basis for the measure of competitiveness between industries producing similar products. According to equation (3.2) and (3.3) if one country is more competitive than country 2, its per unit returns to quasi-fixed resources

will be higher. If competition from country 2 increases then country 1's competitiveness will decline, resulting in diminishing per unit return to primary resource use. In this situation industry 1's absolute competitiveness (how returns this period in country 1 compare to returns in country 2) and relative competitiveness (how changes in returns to country 1 compare to changes in per unit returns to country 2) will decline. In this framework, no contrary rankings can arise between the absolute and relative measures of competitiveness. This is because the shadow price of factors measures the opportunity cost of resource use which is taken to be exogenous.

The absolute measure of competitiveness represents the cumulative impact of changes in the determinants of competitiveness over time. Year to year changes in competitiveness can be assessed via the examination of the industry's relative competitiveness to that of its competitors. If the rate of growth in per unit returns to primary factors is higher in country 1 than in country 2, then country 1's competitiveness is strengthened relative to country 2. Country 2 may, however, still possess an overall competitive advantage, due to its higher level of competitiveness vis-a-vis country 1. Continued rapid growth in per unit returns to quasi-fixed resources in subsequent periods will, however, eventually (ceteris paribus) result in country 1 becoming more competitive than country 2.

The manner in which shadow prices impact the MIC model in this study should not, however, be confused with that of the NP model, which basically represents an accounting measure. The shadow prices entering this analysis results strictly as a consequence of deviations of the quasi-fixed inputs from their optimal long-run equilibrium levels (i.e.,

as a consequence of temporary equilibrium). In addition while DRC assesses the social opportunity cost of resource use, here it is maintained that it is actual returns to resource use that producers are concerned with.

While no general consensus exists on the definition of competitiveness, considerably more agreement exists as to the factors which contribute to competitiveness. Morici (1984) posits that among structural factors, supply conditions play a principal role in determining a country's comparative advantage. He further argues that the amount and quality of physical capital availability per worker, the quality and skill of the labor force, the stock of research and development capital per worker, and the availability of natural resource endowment all contribute to overall productivity and hence to competitiveness. Dogramaci (1981) also argues that productivity is a key determinant of international competitiveness. Productivity advances reduce unit cost of production, increase output and reduce the price of products in competitive markets. In addition higher productivity levels allow factors to receive higher remuneration, while ensuring that the country retains its competitive edge.

Other factors which are likely to play a pivotal role in the determination of competitiveness are technical change and economies of scale. On the issue of technical progress, Harriss (1981) points out that,

> scientific and technological advances have brought incalculable advantages in productivity. Many are striking and obvious, many indirect. Often, accident has played a part (p. 43).

Numerous other studies (i.e., Shumway (1977), Ruttan (1980), Norton and Davis (1981)) also assert the importance of technical change to productivity and hence to competitiveness. Economies of scale may also be

an important determinant of international competitiveness in some industries. While the preponderance of evidence suggests an absence of scale economies in agriculture, evidence of economies of scale has been found in other studies (Griliches, 1964). It therefore appears that the question of economies of scale in agriculture remains an open one. Whatever the outcome, it remains quite likely that economies of scale may be an important variable in measuring differential rates of productivity growth in certain industries/sectors, and hence in accounting for relative cross-country competitiveness.

For measuring and analyzing general trends in trade flows between countries it is changes in relative competitiveness rather than absolute competitiveness that are required. In addition some of the biases arising from the inability to account for some of the non-economic influences on competitiveness are mitigated to the extent that period to period fluctuations in these factors are insignificant.

Two interpretations of MIC are possible. In a static framework $MIC^t_{i,j}$ assesses the absolute competitiveness between countries i and j in period t. If $MIC^t_{i,j}>1$ then, ceteris paribus, the industry in country i has an absolute competitive advantage over its counterpart in country j. On the other hand if $MIC^t_{i,j}<1$, country j's industry is argued to possess absolute competitive advantage over the industry in country i. If $MIC^t_{i,j}=1$ then neither country i nor j has an absolute competitive advantage in this particular industry.

As a relative measure, $MIC^t_{i,j}$ measures the competitiveness between countries i and j at any point in time t, with reference to the base period t=0. If in the base period $MIC^0_{i,j}=1$, then the industry in country

i is argued to be relatively more competitive than the industry in country j if $MIC^t_{i,j} > MIC^0_{i,j}$ where t and 0 are time superscripts denoting the t^{th} and base period, respectively. If with reference to the base period countries i and j possessed no competitive edge over each other, given the relative competitive advantage possessed by country i in time period t, a gap in competitiveness between the two countries will now exist. This will be referred to as a 'competitiveness gap' in favor of country i. Relative competitive advantage/disadvantage in subsequent time periods by country i will cause a widening/narrowing of the competitiveness gap with country j. Conversely, if $MIC^t_{i,j} < MIC^0_{i,j}$, then beginning from a position of 'balanced competitiveness' ($MIC^0_{i,j}=1$) between the two countries in the base period t=0, the industry/sector in country i is losing its competitiveness and a competitiveness gap develops in favor of country j. When $MIC^t_{i,j} = MIC^0_{i,j}$, neither country acquires a competitive advantage in this sector/industry, so there is no change in competitive positions and no competitive gap exists between the two countries.

The central focus of the current model is the investigation of the factors which underscore aggregate sectoral competitiveness between countries. Also of interest are the factors that enable a sector in a particular country to out-perform its counterpart in another country. It is specifically in the context of addressing these issues that the MIC model is developed. It is a positive measure, accounting for trade between the similar sectors based in different countries as it actually occurs. The MIC framework is not suitable for addressing questions relating to the welfare implications of trade; this is because it accounts for both

domestic and trade distortions in addition to efficiency considerations in explaining international competitiveness.

MIC does however distinguish between the source of changes in competitiveness, or identifies the nature of competitiveness. Competitiveness in this regard may be 'true' or 'false'. Competitiveness will be termed 'false' if it is accounted for primarily by higher prices induced by policy measures or by considerations which bear no relationship to the efficiency of production and trade. True competitiveness on the other hand results from factors which have their basis in genuine efficiency considerations or decisions by producing agents.

MIC reconciles the arguments of both those who perceive the competitiveness measure as one independent of all considerations of the source or nature of such competitiveness (whether it is efficiency based or 'fleeting') and those who perceive competitiveness as encompassing only factors grounded in real production efficiency. Adherents to the former view often define competitiveness as the ability to sell. To such adherents the manner in which competitiveness is achieved is unimportant. For proponents of this particular notion of competitiveness it is not necessary to distinguish between sustained or forced competitiveness. Whether competitiveness is achieved as a result of distortionary policies or real phenomena is irrelevant; these influences are only important to the extent that they enable the firm to sell profitably.

To adherents of the second efficiency-based notion of competitiveness, the source of such competitiveness is critical. If a firm's ability to sell is based entirely on artificially high prices, exchange rate misalignment, or policy induced distortions, proponents of

this view would argue that the firm is not competitive at all, even if it managed to outsell competitors in other countries. Those who favor this view believe that competitiveness refers to a situation where firms sell and acquire market share in the absence of any assistance (i.e, based solely on efficiency considerations).[2] This notion of competitiveness is predicated on the view that it is necessary to augment if not supplement the analysis of firm cost, demand and price competitiveness with a continuous forward looking examination of its productivity levels and trends relative to that of its competitors. This is because, as Sudit (1984) points out, a more favorable outlook for profitability will exist if the firm has an overall significant relative productivity advantage in relation to its competitors.

The MIC embraces both these notions of competitiveness. The first notion is captured in the short-run MIC decomposition developed in the next section. The term 'short-run' is used in reference to the production process (derived from the restricted profit function) and does not in any way characterize the MIC measure. If however one is prepared to argue that in the short run distortions such as subsidies and deficiency payments are possible which are untenable in the long run scenario, then in some limited sense use of a short-run notion of MIC could be rationalized. The MIC measure developed via the restricted profit function accounts for both domestic and trade distortions in addition to efficiency considerations in accounting for international competitiveness. The MIC developed via the long-run profit function, however, encompasses only factors considered to

[2]This view of competitiveness closely approximates but does not coincide with the conventional theories of trade in terms of comparative advantage.

be real or sustainable, reminiscent of the second view of competitiveness.

The use of the term 'long run' is an artifact of the nature of the technology rather than a characterization of MIC.[3] Whereas elements of both real and forced competitiveness are present in the model derived from the short-run profit function, only factors based in the efficiency of production and trade (real factors) are present in the MIC derived via the long-run profit function. Therefore, the influence of both real and forced competitiveness present in MIC can be assessed from its decomposition both via the short- and long-run frameworks alluded to above.

MIC Development and Specification

This section uses short-run production theory to develop an empirically estimable model of competitiveness across countries. The MIC framework allows differences in factor usage and efficiency to influence competitiveness over time. Acquiescence to the view that inter-country differences are central to trade constitute implicit acceptance of resource endowments and technology explanations as key components in the determination of the basis for trade.

Assume that the producer behavior is represented by a restricted profit function, given by

$$\pi_{it} = P_{it} \cdot y_{it}(P_{it}, w_{it}, z_{it}, T_{it})$$

[3] 'With' and 'without' policy induced distortions may be more suitable terminology for characterizing the 'short-' and 'long-run' MIC's respectively. Even used in the most restricted sense, no assumption can be made that pre-existing 'short-run' policy-induced distortions will be phased out in the 'long-run'.

$$-C_{it}(y_{it}(P_{it}, w_{it}, z_{it}, T_{it}), w_{it}, z_{it}, T_{it}) \tag{3.6}$$

where y_{it} is the profit maximizing level of industry output in country i at time t; P_{it} is the industry product price in country i at time t; w_{it} is a vector of variable inputs prices at time t in country i; z_{it} is a vector of quasi-fixed or primary inputs at time t in country i; T_{it} is a measure of disembodied technical change in country i at time t; and C_{it} represents the minimum cost of producing a vector of outputs y_{it}, conditional on the set of exogenous characteristics, (z_{it}, T_{it}).[4] This form of the restricted profit function was chosen in preference to the more familiar $\pi(P,w,z,t)$, because it facilitated an easier disentanglement of cost and revenue effects. The two formulations are however equivalent to each other, but while equation (3.6) allows a fairly disaggregrated analysis of interactions, the interactions are all lumped together in the form given by the more conventional statement of the restricted profit function.

The difference in restricted profit between country i and j, at a given point in time, is found by total differentiation of the restricted profit function given by equation (3.6). Differentiating equation (3.6), and making the appropriate substitutions, gives

$$d\pi_{it} = P_{it}\left(\frac{\partial Y_{it}}{\partial P_{it}}\right) dP_{it} + P_{it}\left(\frac{\partial Y_{it}}{\partial w_{it}}\right) dw_{it} + P_{it}\left(\frac{\partial Y_{it}}{\partial z_{it}}\right) dz_{it} + P_{it}\left(\frac{\partial Y_{it}}{\partial T_{it}}\right) dT_{it} + Y_{it} dP_{it}$$
$$- \left(\frac{\partial C_{it}}{\partial Y_{it}}\right).\left(\frac{\partial Y_{it}}{\partial P_{it}}\right) dP_{it} - \left(\frac{\partial C_{it}}{\partial Y_{it}}\right).\left(\frac{\partial Y_{it}}{\partial w_{it}}\right) dw_{it} - \left(\frac{\partial C_{it}}{\partial Y_{it}}\right).\left(\frac{\partial Y_{it}}{\partial T_{it}}\right) dT_{it} \tag{3.7}$$

---

[4]Producer behavior in country j is also represented by a restricted profit function of the form given by equation (3.6), in country j's restricted profit function, however, the subscript i is replaced with j. Consequently, subsequent mathematical manipulations are only carried out with respect to country i, the mathematical manipulations for country j are identical except for the difference in subscript notation.

$$- \left(\frac{\partial C_{it}}{\partial Y_{it}}\right) \cdot \left(\frac{\partial Y_{it}}{\partial z_{it}}\right) dz_{it} - \left(\frac{\partial C_{it}}{\partial z_{it}}\right) dz_{it} - \left(\frac{\partial C_{it}}{\partial w_{it}}\right) dw_{it} - \left(\frac{\partial C_{it}}{\partial T_{it}}\right) dT_{it}$$

Dividing by restricted profits, π_{it} and redefining variables, consistent with their elasticities and share measures yields

$$\frac{d\pi_{it}}{\pi_{it}} = \epsilon_s \mathfrak{R}\, d\ln P_{it} + \epsilon_{Yw} \mathfrak{R}\, d\ln w_{it} + \frac{\dot{A}}{A} \mathfrak{R}\, dT_{it} + \mathfrak{R}\, d\ln P_{it} - (\epsilon_{cY} \cdot \epsilon_s) \mathfrak{C}\, d\ln P_{it}$$

$$- (\epsilon_{cY} \cdot \epsilon_{Yw}) \mathfrak{C}\, d\ln w_{it} - (\epsilon_{cY} \cdot \epsilon_{Yz}) \mathfrak{C}\, d\ln z_{it} - \epsilon_{cY} \frac{\dot{A}}{A} \mathfrak{C}\, dT_{it}$$

$$- S_w d\ln w_{it} + S_z d\ln z_{it} - \frac{\dot{B}}{B} dT_{it} \qquad (3.8)$$

where $\mathfrak{C} = \frac{C_{it}}{\pi_{it}}$ and $\mathfrak{R} = \frac{P_{it} \cdot Y_{it}}{\pi_{it}}$ equals the ratio of costs to restricted profits, and the ratio of total revenue to restricted profits, respectively. $\dot{A}/A$ represents the primal rate of technical change, defined as the proportional shift in the production function over time.

Specifically, $\dot{A} = (\partial Y_{it}/\partial T_{it})(1/Y_{it})$. Similarly the dual rate of technical change defined as the proportionate shift in the cost function is given as $\dot{B} = (1/C_{it})(\partial C_{it}/\partial T_{it})$. After collecting terms and rearranging, equation (3.8) becomes:

$$d\ln\pi_{it} = (1+\epsilon_s)\mathfrak{R}\, d\ln P_{it} - (\epsilon_{cY} \cdot \epsilon_s) \mathfrak{C}\, d\ln P_{it} + [(\epsilon_{Yw}\mathfrak{R} - S_w - (\epsilon_{cY} \cdot \epsilon_{Yw})\mathfrak{C})]\, d\ln w_{it}$$

$$+ [(\epsilon_{Yz}\mathfrak{R} + S_z - (\epsilon_{cY} \cdot \epsilon_{Yz})\mathfrak{C})]\, d\ln z_{it} + \mathfrak{R} \frac{\dot{A}}{A} dT_{it} - \mathfrak{C} \frac{\dot{B}}{B} dT_{it} - \epsilon_{cY} \frac{\dot{A}}{A} \qquad (3.9)$$

The shares are obtained via application of Shepherd's Lemma (Silverberg, 1978; Varian, 1984). The variable factor shares are obtained from

$$\frac{\partial \ln C}{\partial \ln w_i} = S_i \qquad i = 1, .., 3. \qquad (3.10)$$

While the quasi-fixed input shares are obtained by

$$\frac{\partial \ln C}{\partial \ln z_j} = -S_j \qquad j=1,2. \tag{3.11}$$

Ohta (1974) shows that, in the case of nonconstant returns to scale shifts in the cost function are not equivalent to shifts in the production function. In the case of nonconstant returns to scale

$$-\frac{\dot{B}}{B} = \epsilon_{CY}\frac{\dot{A}}{A} \tag{3.12}$$

Substituting this relationship into equation (3.9), yields the measure of changes in restricted profits (value added) as

$$d\ln\pi_{it} = [(1+\epsilon_s)\mathfrak{R} - (\epsilon_{CY}\cdot\epsilon_s)\mathfrak{C}]\,d\ln P_{it} + [(\epsilon_{Yw}\mathfrak{R} - S_w - (\epsilon_{CY}\cdot\epsilon_{Yw})\mathfrak{C})]\,.\,d\ln w_{it}$$

$$+ [(\epsilon_{Yz}\mathfrak{R} + S_z - (\epsilon_{CY}\cdot\epsilon_{Yz})\mathfrak{C})]\,d\ln z_{it} + \mathfrak{R}\frac{\dot{A}}{A}dT_{it} \tag{3.13}$$

where ϵ_{Yv} is the elasticity of output with respect to a change in the price of the variable input prices and ϵ_{Yz} the elasticity of output with respect to a change in the level of quasi-fixed factors. ϵ_s represents the elasticity of supply, ϵ_{CY} the cost-output elasticity and S_w and S_z the cost shares of variable and quasi-fixed factors respectively. From equation (3.2) the measure of international competitiveness (MIC) is the ratio of changes in value added functions (of the form represented by equation (3.13)), appropriately subscripted for country i and j respectively (i.e., $\frac{d\ln\pi_{it}}{d\ln\pi_{jt}}$).

The cost and supply elasticities characterize the short-run consequences of changes in the exogenous variables, conditional on the level of z_{it}. The elasticity of supply represents the change in output in the short run when an exogenous change in the product price occurs. Under the assumption of the restricted technology as an appropriate characterization of production inter-relationships, all the cost elasticities are dependent on the extent of quasi-fixity. The elasticity

of cost with respect to output is the change in total costs resulting from a one unit change in output. As shown in equation (3.13), the cost-output elasticity is constrained by the degree to which quasi-fixed inputs can adjust. Another interpretation of the cost shares, S_z and S_w, are as elasticities of variable cost with respect to the level of the quasi-fixed factor and variable input prices, respectively.

Differences in the rate of growth of restricted profits (equation (3.13)) between industries constitute the measure of relative competitiveness. The measure represents the fundamental equation of measured differentials in short-run industry competitiveness over time. Equation (3.13) shows that the measure of changes in industry competitiveness may be decomposed into:

(a) the logarithmic difference in the industry or sectoral product price;

(b) the logarithmic difference in industry or sectoral factor prices;

(c) the logarithmic difference in quasi-fixed input utilization between industries and

(d) the logarithmic difference in the rates of technical change weighted by the appropriate elasticity measures, cost and revenue shares.

The measure of changes in bilateral competitiveness possesses elements of both notions of competitiveness discussed in the previous section. In regard to the first notion of competitiveness (i.e, that it makes no difference whether competitiveness arises from factors rooted in real differences in the structure of production or from other means), the

MIC gives the combined effect of measured differences in various factors on the ratio of restricted profits between countries--the indicator variable for relative sectoral/industry competitiveness. If however one subscribes to the notion of competitiveness emanating from real differences in the efficiency of production and trade, then the decomposition of MIC allows insights into the relative importance of real factors in the determination of the rate of measured competitiveness between countries.

The first two terms of equation (3.13) represent the product price effect (restricted or gross terms of trade effect). The term 'gross' is used to qualify the use of the terms of trade concept, since it is not adjusted for changes in either traded inputs or for intermediate products traded between countries. Equation (3.13) indicates that the effect of changes in the relative gross terms of trade depends on the relative cost-output elasticity and the relative elasticities of supply between the two countries. In addition, the relative restricted terms of trade will be affected by other influences such as domestic and trade policies and supply and demand conditions for the product between countries. While prices are subject to demand and supply conditions, with profit maximization and perfectly competitive markets, the sector in country i can establish its competitiveness by exporting to country j on the basis of relative cost and profitability advantages.

The second set of terms highlights the impact of relative factor price movements on changes in the bilateral competitiveness index. In a manner similar to the restricted terms of trade effect, various factors also influence the relative factor price terms. Such factors though, are

assumed to be given to the sector/industry and the short-run competitiveness index is independent of the processes by which they are generated. As such, the direct and indirect impact of both domestic and trade policy instituted to create and maintain competitiveness are captured, along with real variations in relative factor proportions and demand and supply movements. The decomposition suggests that the impact of these effects on the bilateral competitiveness index is by no means trivial. It depends on relative movements in observed shares, the elasticity of cost with respect to factor price changes and the relative magnitudes of revenue and cost shares in restricted profits. In general, factor prices and costs will move together, while factor prices and restricted profits will move in opposite directions. The complex interactions, however, warrant an empirical means of determining the magnitudes of these effects.

Another characteristic of equation (3.13) is that the industry with the higher rate of technological progress relative to the industry in the other country, will have a slower rate of growth in costs, which will result in higher rates of profit. The impact of technological change is therefore to unambiguously reduce costs in the sector that is relatively more progressive in relation to the other country's sector. For sectors characterized by similar stages of development, the transfer of new technology is likely to be great, causing the benefits of rapid technology adaption to be short lived. Such influences on competitiveness, short-lived though they might be, are real since they result from advantages based on genuine economic differences in the structure of production between countries. Such differences in the rate of technological progress

between countries will be referred to as the technical change gap throughout the remainder of this study.

CHAPTER IV
MODEL SPECIFICATION, ESTIMATION AND EMPIRICAL RESULTS

Introduction

This chapter develops empirically estimable structural models for the agricultural sectors of the U.S. and Canada and uses them to construct the bilateral competitiveness index developed in the previous chapter. The empirical specifications which forge the link between the theoretical model and the bilateral measure of competitiveness are presented in section two. Section three discusses empirical estimation of these models. Empirical results are presented in section four, along with various tests on the structure of production in both countries. The theoretical consistency of the estimated models are also investigated by evaluation of the usual regularity conditions.

Model Specification

The technology under which the firm operates can be represented by a restricted profit function of the form

$$\pi_{it} = P_{it}Y_{it} - C_{it}(Y_{it}(P_{it}, w_{it}; z_{it}, T_{it}), P_{it}, w_{it}; z_{it}, T_{it}) \qquad (4.1)$$

This particular form of the restricted profit function was chosen over the more usual representation, $\pi_{it}(P_{it}, w_{it}; z_{it})$, to facilitate investigation of the impacts of the various components of restricted profit. Equation (3.6) is restated as equation (4.1), since the focus in this section is on the development of empirical structural relationships for U.S. and Canadian agriculture. The estimation results of these structural relationships,

will be used in the construction of the competitiveness index represented in the preceding chapter by equation (3.13).

Given technology and prices across firms and profit maximizing behavior, the first-order condition for unconstrained profit maximization in terms of the restricted profit function is

$$\frac{\partial \pi_{it}}{\partial Y_{it}} = P_{it} + Y_{it}\frac{\partial P_{it}}{\partial Y_{it}} - \frac{\partial C_{it}}{\partial Y_{it}} = 0 \qquad (4.2)$$

or marginal revenue (MR) is equal to marginal cost (MC). If instead the product market is assumed to be perfectly competitive, the first order condition for unconstrained profit maximization requires that

$$\frac{\partial \pi_{it}}{\partial Y_{it}} = P_{it} - \frac{\partial C_{it}}{\partial Y_{it}} = 0 \qquad (4.3)$$

or price equals marginal cost.

In both cases, the second-order condition requires that the slope of the MC function be positive, or that MC must be rising. Equations (4.2) and (4.3) suggest that the cost function may be used along with the profit maximization assumption to represent the firm's optimization problem. Traditionally, in the estimation of the cost function the level of output is assumed exogenous. In the empirical implementation of equation (4.2), an endogeneity problem arises in using the cost function along with the profit-maximization assumption. This is because the profit maximizing level of output (Y_{it}), is an endogenous choice variable in the restricted profit function.

The translog cost function is chosen to represent the underlying technology in the U.S. and Canada. As a member of the class of flexible functional forms, the translog function does not impose a priori restrictions on a firm's technical substitutability. The function is

quadratic in logarithms and is one of the family of second-order Taylor-series approximations to an arbitrary cost function.

United States Model

To operationalize the methodology, a single output translogarithimic form for the variable cost function with homotheticity imposed is specified.[1]

$$\begin{aligned} \ln C = {} & \alpha_0 + \alpha_Y \ln Y + \sum_{i=1}^{3} \beta_i \ln W_i + \sum_{i=1}^{2} \phi_i \ln Z_i + 1/2\, \alpha_{YY} \ln(Y)^2 \\ & + 1/2 \sum_{i=1}^{3}\sum_{j=1}^{3} \gamma_{ij} \ln W_i \ln W_j + 1/2 \sum_{i=1}^{2}\sum_{j=1}^{2} \phi_{ij} \ln Z_i \ln Z_j \\ & + \sum_{i=1}^{3}\sum_{j=1}^{2} \rho_{ij} \ln W_i \ln Z_j + 1/2 \alpha_{tt} (T)^2 \\ & + \alpha_{Yt} \ln Y . T + \sum_{i=1}^{3} \alpha_{it} \ln W_i . T \\ & + \sum_{i=1}^{2} \rho_{it} \ln Z_i . T + \xi_c \end{aligned} \tag{4.4}$$

where C is the variable cost of production, Y is aggregate output, W_i (i=1,2,3) are vectors of variable input prices, z_i (i=1,2) are vectors of quasi-fixed or primary inputs and T is a time trend included to capture disembodied technical change. ξ_c is a vector of additive disturbance terms, appended to reflect errors in the optimization process. The vector of disturbances is assumed to be jointly normally distributed with mean zero and non-singular covariance matrix, Ω (i.e, $\xi_c \sim iid(0,\Omega)$). The parameter restriction for symmetry and homogeneity of degree one in prices were imposed a priori. These restrictions implied that

[1]The homotheticity assumption implies that the elasticity of size and scale are equivalent and that input substitution is independent of the level of output. Discussion of the parametric restrictions implied by homotheticity as well as other restrictions is deferred until a later section.

$\gamma_{ij} = \gamma_{ji}, \quad \phi_{ij} = \phi_{ji};$

$$\sum_{i=1}^{3} \beta_i = 1; \tag{4.5}$$

$$\sum_{i=1}^{3} \gamma_{ij} = \sum_{i=1}^{3} \gamma_{ji} = \sum_{i=1}^{3} \gamma_{Yi} = \sum_{i=1}^{3} \rho_{ij} = \sum_{i=1}^{3} \alpha_{it} = 0, \quad \forall j.$$

From Shephard's Lemma, the derivatives $\partial \ln C/\partial \ln W_i$ are equal to the shares of the variable factors in variable cost, $S_i = W_i X_i / C$. The application of Shepherd's Lemma to equation (3) results in n share equations of the following form

$$S_i = \beta_i + \gamma_{Yi} \ln Y + \sum_{j=1}^{3} \gamma_{ij} \ln W_j + \sum_{j=1}^{2} \rho_{ij} \ln Z_j + \alpha_{it} T + \xi_i \qquad i = 1,2,3 \tag{4.6}$$

where again the ξ_i's represent additive disturbance terms indicative of error in optimization, $\xi_i \sim iid(0,\Omega)$. To use the translog cost function along with the profit-maximizing condition, under the assumption of perfectly competitive product markets, additional equations must be generated to represent the optimal choice of output. Taking the derivative of the variable cost function with respect to output yields

$$\frac{\partial \log C}{\partial \log Y} = \frac{\partial C}{\partial Y} \frac{Y}{C} = \frac{PY}{C} \tag{4.7}$$

Let R denotes the share of revenue in variable cost PY/C.[2] In terms of the parameters of the translog function the revenue share equation may be written as

$$R = \alpha_i + \alpha_{YY} \ln Y \tag{4.8}$$

which yields the familiar first-order condition, price equals marginal cost necessary for profit maximization under the assumption of competitive markets.

---

[2]Equation (4.7) utilizes the relationship $\partial C/\partial Y = P$.

Imposing the monotonocity and concavity conditions cannot be accomplished globally via restrictions on model parameters. Instead these conditions are checked locally. The necessary and sufficient condition for monotonocity in the cost function is that,

$$\frac{\partial C}{\partial W_j} = \frac{\partial \ln C}{\partial \ln W_j} \cdot \frac{C}{W_j} > 0 \quad \forall_j. \tag{4.9}$$

In terms of the translog function this requires the predicted values of the cost shares to be greater than zero, ($\hat{S}_j > 0$). Monotonocity in output also requires that the partial derivative of the cost function with respect to output be non-negative. In terms of the parameters of the cost function the necessary and sufficient condition for this is that,

$$\frac{\partial \ln C}{\partial \ln Y} = \alpha_i + \alpha_{YY} \ln Y > 0. \tag{4.10}$$

The cost function must also be concave w. Satisfying this condition requires that the Hessian matrix of second order partials of the cost function with respect to factor prices, $H = \frac{\partial^2 C}{\partial W_i \partial W_j}$, be negative semi-definite. This condition can also be evaluated through the matrix of Allen elasticities of substitution. Following Uzawa (1962), the Hicks-Allen elasticities of substitution can be derived from the partial derivatives of the cost function as follows

$$\sigma_{ij} = \frac{CC_{ij}}{C_i C_j} \tag{4.11}$$

where $C_{ij} = \frac{\partial^2 C}{\partial W_i \partial W_j}$, $C_j = \frac{\partial C}{\partial W_j}$, $\forall$ i,j.

For the translog model the Allen elasticity of substitution (AES) are given by

$$\sigma_{ii} = \frac{(\gamma_{ii} + S_i^2 - S_i)}{S_i^2} \tag{4.12}$$

$$\sigma_{ij} = \frac{(\gamma_{ij} + S_i S_j)}{S_i S_j} \qquad (4.13)$$

Expressions for the AES's can also be derived from the relationship $\epsilon_{ij} = S_j . \sigma_{ij}$. The ϵ_{ij}'s denote the factor demand elasticities obtained from the parametric share equations. The elasticities may be calculated from share for the i-th input in variable cost.[3]

Canadian Model

The system for Canada was quite similar to that of the U.S., except for the assumption of imperfectly competitive product markets which was required in estimating the Canadian model.[4] The model estimated for Canada consisted of the cost function, the n-1 share equations, a profit-maximizing condition and an aggregate demand function. The final form of the estimated model consisted of the cost function equation (4.4), with symmetry, homogeneity, and homotheticity imposed, the n-1 share equations, equation (4.6) and the revenue share equation.

If the product market is assumed to be imperfectly competitive the profit maximization condition becomes

$$R = (\alpha_i + \alpha_{YY} \ln Y + \sum_{i=1}^{3} \gamma_{Yi} \ln W_i + \sum_{i=1}^{2} \rho_{Yi} \ln Z_i + \alpha_{Yt} . T)(1 + \frac{1}{\eta_i})^{-1} \qquad (4.14)$$

where η_i is the own-price elasticity of demand for aggregate output, and R denotes the share of revenue in variable cost PY/C. If the assumption of

[3]See Chambers (1988).

[4]Considerable problems were encountered in satisfying the second-order conditions, during estimation of the Canadian model with the assumption of perfect competition maintained. The marginal cost function became positive, when instead the more general assumption of imperfect product markets was assumed. The imperfect competition assumption is justified on the grounds that Marketing Boards in Canada, possess some degree of monopoly power in determining the price and output for some commodities.

competitive product markets is made $\eta_i \to \infty$, and equation (4.14) reduces equation (4.7).

Once the assumption of imperfect competition is made and the profit maximization takes the form of equation (4.14), additional information is required to identify the elasticity of demand parameter in the system.[5] Such additional information is brought into the model by specifying a demand function of the form

$$\ln Y = \delta_0 + \delta_1 \ln(P/CPI) + \delta_2 \ln(NI) + \xi_d. \tag{4.15}$$

where NI is real per capita disposable income, CPI is the consumer price index and ξ_d represents the error term, $\xi_d \sim iid(0,\Omega)$. Fuss and Waverman (1981) argue that the demand function given by equation (4.15), may be viewed as a first-order approximation to an arbitrary demand function, where the level of output is weakly separable from all other goods in the consumer's utility or cost function, and the aggregate price index of these other commodities is represented by the CPI.

Modelling the technology in the U.S. and Canada in this manner facilitates the development of an expression for the elasticity of supply to be derived from the revenue share equation. This is because there now exists a direct relationship between the optimal or profit maximizing level of output and cost minimizing behavior by firms. The link between the cost minimization and profit maximization is forged by the revenue

[5]Studies by Taylor and Kilmer (1988) and Appelbaum and Berecham (1991), both included additional information in a manner consistent with the specification pursued here. While Capalbo and Antle (1988) did not specify the demand side as a means of incorporating additional information into the system, additional information was brought in by including the revenue share equation in estimation.

equation.[6] Taking logarithms and partially differentiating equation (4.14) or equation (4.7) with respect to the profit maximizing level of output yields

$$\epsilon_x = \frac{R}{R^2 + \alpha_{QQ} - R} \tag{4.16}$$

The elasticities of cost with respect to a change in the level of the quasi fixed input ϵ_{cz}, and the elasticities of cost with respect to a change in variable input prices, $\epsilon_{cw}=S_i$, are derived directly by differentiation of the cost function with respect to quasi fixed inputs and variable input prices, respectively. The expression for ϵ_{cz} is given by

$$\frac{\partial \ln C}{\partial \ln Z_i} = \phi_i + \phi_{ij} \ln Z_j + \rho_{ij} \ln W_i + \rho_{it} T. \tag{4.17}$$

The rate of technical change is derived by differentiation of the cost function with respect to time

$$\frac{\partial \ln C}{\partial t} = \alpha_t + \alpha_{it} \ln W_i + \rho_{it} \ln Z_i + \alpha_{tt} . T. \tag{4.18}$$

Under the assumptions of constant returns to scale and competitive equilibrium, the rate of technological change is equivalent to the rate of TFP. The estimation of the translog cost function under the assumption of profit maximization therefore incorporates all the information pertinent to the development of the bilateral competitiveness index, MIC.

---

[6]The concept of a supply function and the assumption that Canadian firms possess some degree of monopoly power are inconsistent. The is because the marginal cost curve of the monopolist is not the supply curve, as in the case of the perfectly competitive firm. As such, no unique relationship exists between price and quantity in the Canadian model. From equation (4.14), the relationship between quantity and product price in Canada is shown to be dependent on marginal revenue and the elasticity of demand.

Method of Estimation

The traditional method of estimation for the cost function and share equations is usually some variant of the Seemingly Unrelated Regression (SUR) Procedure. However since one share equation must be deleted, Iterated SUR, which is asymptotically equivalent to Maximum Likelihood estimation, must be used to ensure the estimated parameters are invariant to the equation deleted.[7]

For the U.S. specification, however, this method of estimation is not appropriate and will result in parameter estimates which are inconsistent and inefficient. The problem is that the explanatory variables in the system of equations consisting of the cost function (equation (4.4)), the share equations (equation (4.6)) and the profit maximizing condition (equation (4.7)), are correlated with the disturbance terms. To obtain consistent estimates of the parameters the simultaneity must be accounted for. In addition, the level of output is assumed to be jointly determined and an endogeniety problem exists since the profit maximizing condition is used in the derivation of the revenue condition. This suggest that some instrumental variable estimator should be used to account for the endogeniety. The endogeniety problem was also another reason for adopting the homotheticity assumption. Without homotheticity, which reduced the number of endogenous variables to be estimated, identification problems would be encountered rendering the models underidentified.

The system could potentially be estimated via three stage least square (3SLS). The problem is that the 3SLS procedure may not be invariant

[7]See Greene (1990).

to the equation deleted. The invariance property is however attained by iterating the 3SLS procedure until the residual covariance matrix and the estimated parameter estimates converge. Iterated 3SLS (I3SLS) with instrumental variables was used in the estimation of the system of equations for the U.S. The I3SLS is consistent and asymptotically efficient, in addition in large samples the procedure is asymptotically equivalent to the ML procedure.

The model for Canada is specified under the assumption of imperfectly competitive product markets and consisted of the demand function, equation (4.15), in addition to equations (4.4), (4.6), (4.14).[8] From an econometric standpoint, since a function of any endogenous variable is itself endogenous, an endogeneity problem exists because endogenous output enters as a function of numerous other variables in the system. This causes the system of equations characterizing Canadian agriculture to be non-linear. From a theoretical standpoint an endogeneity problem also exists involving output because the profit maximizing conditions are used in the derivation of the revenue share equations.

The model was thus estimated using Amemiya's (1977) iterative three-stage least squares estimator (I3SLS). The I3SLS procedure yields

---

[8]The assumption of competitive product markets was determined to be inappropriate for Canada. This implied that firms were either not profit maximizers or that they were profit maximizers but were not competitive. Model diagnostics suggested that profit maximization was not an assumption which appeared particularly objectionable, leading us to concentrate on the possibility that the assumption of competitive product markets may be inappropriate. Relaxing the marginal cost pricing assumption for the substantially more general assumption of imperfectly competitive product markets, caused marginal cost to become positive in accordance with a priori theoretical expectations. Coincidentally or otherwise, the period over which the model was not well behaved (1980-1989), coincides with the period of unprecedented levels of government payments to Canadian agriculture.

asymptotically consistent estimates of the parameters of the simultaneous-equation system. As with the U.S. model the instruments were formed from all the exogenous variables in the system in addition to the variables suggested by the demand equation.

The I3SLS procedure utilizes information on the correlation of the stochastic disturbance terms of the structural equations from 2SLS to improve asymptotic efficiency. Given the assumption that the disturbance terms are additive and follow a multivariate normal distribution, the estimator is efficient in the sense that it attains the Cramer-Rao bound. The estimator is more robust than maximum likelihood in that it does not depend on the assumption of normality. It is also less sensitive to slight misspecification errors than the maximum likelihood estimator.

Since the cost shares sum to unity, the estimated covariance matrix will be singular, thus one of the share equations must be omitted. The parameter estimates are invariant to the equation deleted. Again as with the deleted equation in the U.S. model the coefficients of the excluded equation may be obtained after estimation by using the parameter relationships implied by the linear homogeneity restrictions.

Empirical Results

In this section estimation results for the U.S. and Canadian models are presented. The variables in the model included the price of intermediate inputs, energy and hired labor. The two fixed inputs are operator-family labor and capital. A description of the data and its construction is given in the data appendix. Model results are discussed separately for each country. In addition, the results of various tests conducted on the production structure of the two countries will be

presented. Finally, to assess the consistency of the parameter estimates obtained from the translog specifications, comparison with other studies will be undertaken.

Canadian Model Estimates

The Canadian model consisting of equations (4.4), (4.6), (4.14) and 4.15) was estimated using data over the 1961-1989 period. The cost function, share equations and profit maximizing condition with symmetry, homogeneity and homotheticity imposed was estimated as a system along with the demand function. The model was estimated with Amemiya's non-linear three stage least square estimator (NL3SLS) with the restrictions imposed reducing the number of independent parameters to be estimated to twenty six.

The full set of parameter estimates are presented in Table 4.1. Of the twenty six parameters estimated, fifteen had parameter values twice the size of their respective standard errors. Overall the Canadian model exhibited fairly good fits according to the adjusted R^2 for individual equations. The adjusted R^2 statistics were 0.939, 0.932, and 0.888 for the cost function, the intermediate-input share equation and the energy share equation, respectively. For the demand function and the revenue share equation the adjusted R^2 statistics were .837 and .666, respectively.[9]

The demand equation was estimated along with the revenue-share (marginal revenue pricing) equation. The own-price elasticity of demand for agricultural output in Canada was inelastic evaluated at the geometric mean of the data in accordance with conventional demand theory. This also

[9]The hired labor share equation was omitted to maintain theoretical consistency with the restrictions imposed on the system.

Table 4.1 Parameter Estimates for Translog Variable Cost Model, Canada 1961-1989.

Parameter	Estimate	Parameter	Estimate
		Canada	
α_0	602.606 (1283.510)[a]	ρ_{11}	-0.301 (0.109)
α_Q	-5.896 (2.364)	ρ_{12}	-0.169 (0.036)
α_{QQ}	0.974 (0.271)	ρ_{21}	0.290 (0.015)
β_1	4.653 (1.483)	ρ_{22}	0.006 (0.006)
β_2	2.765 (0.528)	α_t	-3.883 (1.570)
γ_{11}	0.075 (0.068)	α_{tt}	0.014 (0.013)
γ_{22}	0.082 (0.026)	α_{1t}	-0.157 (0.003)
γ_{12}	0.069 (0.021)	α_{2t}	-0.001 (0.0001)
ϕ_1	-67.674 (194.794)	ρ_{1t}	0.299 (0.501)
ϕ_2	8.462 (26.496)	ρ_{2t}	-0.044 (0.033)
ϕ_{11}	5.400 (14.580)	δ_0	19.026 (0.753)
ϕ_{22}	0.491 (0.703)	δ_1	-0.801 (0.063)
ϕ_{12}	-1.042 (1.852)	δ_2	-0.664 (0.086)

[a] Asymptotic standard errors in parentheses.

conformed with apriori expectations in regard to the nature of demand for agricultural products.[10]

In order to be well defined, the estimated variable cost function should satisfy the regularity condition that it be non-decreasing and concave in the prices of variable factors, non-increasing and convex in the levels of the fixed factor and non-decreasing and convex with respect to output. Concavity of the cost function with respect to factor prices is satisfied if the Hessian matrix is negative semi-definite, while convexity with respect to output is established if the Hessian matrix of second-order partials is positive semi-definite. The estimated model satisfied the concavity and convexity conditions at each sample point. In addition, if the cost function is well-behaved, the partial derivatives of the cost function with respect to the levels of each of the quasi-fixed factor should be negative. This condition was checked and accepted at most sample points and at the geometric means of the data.[11]

Various hypotheses concerning the estimated model were tested. These provide a means of assessing the appropriateness of the functional specification and assumptions made in modelling the production technology in Canadian agriculture.

---

[10]The elasticity of demand was -.8016 with an associated standard error of .0368. Though the income elasticity of demand term was statistically significant, its sign violated standard theoretical sign conventions.

[11]An evaluation of the derivatives of the cost function with respect to quasi-fixed labor indicated that twenty-six of the twenty-nine parameters were negative, the number of parameters with respect to the other quasi-fixed factor capital, satisfying the sign condition were twenty-two.

The first test carried out on the technology was a test of quasi-fixity. The test is developed by considering a parametric form of the translog system consisting of the cost function itself, and the n-1 share equations, against the alternative hypotheses consisting of the cost function, the share equations and the following shadow value equations

$$\frac{\partial \ln C}{\partial \ln Z_i} = -u_i = \phi_i + \phi_{ij} \ln Z_j + \rho_{ij} \ln W_i + \rho_{it} T. \quad \forall_{i,j} \tag{4.19}$$

Since the share and shadow equations are derived explicitly from the cost function, under the assumption of long-run equilibrium for all inputs, the parameters of the set of equations (4.6) and (4.19) are contained in equation (4.4) (Taylor and Kalaitzandonakes, 1990). If only the parameters of the share equation are taken to be contained in the cost function, the null hypotheses that some fixity is justified in specifying the production structure may be tested to determine whether the parameters of the shadow value equations are contained in the cost function. The test is implemented by a version of the Hausman specification test given by

$$M = T(\tilde{\beta}_0 - \hat{\beta}_0)' V^{-1} (\tilde{\beta}_0 - \hat{\beta}_0) \tag{3.20}$$

where $\tilde{\beta}$ and $\hat{\beta}$ denote the unrestricted and restricted parameter estimates respectively, $\tilde{V}$ and $\hat{V}$ the unrestricted and restricted covariance matrix, and where $V = (\tilde{V} - \hat{V})$ has a χ^2 distribution with degrees of freedom equal to the number of restrictions contained in the null hypotheses.

Rejecting the null hypotheses is tantamount to arguing that all inputs do not adjust instantaneously to their log-run equilibrium levels, thereby lending support to the quasi-fixed specification of the model. To fail to reject would suggest that the short-run model implying temporary equilibrium is a misspecification, and that the long-run (all inputs variable) specification is more appropriate.

A test for the appropriateness of specifying technology by a variable cost function with capital and labor as quasi-fixed was performed on the Canadian model.[12] Application of the test supported the hypothesis that characterization of the technology as inclusive of some degree of fixity was justified in Canadian agriculture. Test results are reported in Table 4.2. The calculated value of the test statistic was 86.48 which exceeded the critical $\chi^2_{(9)}$ value of 19.67. Thus the null hypothesis of equality between the observed market prices and their respective shadow values for operator-family labor and capital inputs in Canadian agriculture was rejected. This result is strengthened by the use of the instrumental variable estimator in the estimation process. Taylor and Kalaitzandonakes argue that while the quasi-fixed inputs may be exogenous to the firm's decision, it may not be exogenous in an econometric sense. This is because the error terms may be correlated with the levels of the quasi-fixed factors in the model. The appropriate choice of instruments will however solve this problem, as one criteria for the choice of instruments is that they are uncorrelated with the disturbance terms (see Judge et al. (1980)).

The hypotheses that the technology was of the Cobb-Douglas form was also tested. This requires the following restrictions on the parameter set

$$\alpha_{YY} = \alpha_{tt} = \alpha_{Yt} = 0;$$
$$\sum_{i=1}^{3} \gamma_{ij} = \sum_{i=1}^{2} \phi_{ij} = \sum_{i=1}^{3} \gamma_{Yi} = \sum_{i=1}^{3} \rho_{ij} = \sum_{i=1}^{2} \rho_{Yi} = \sum_{i=1}^{3} \alpha_{it} = \sum_{i=1}^{2} \rho_{it} = 0 \quad \forall_j. \tag{4.21}$$

Long-run constant returns to scale was tested by the imposition of the following parametric restrictions

[12]This test was originally suggested by Schankerman and Nadiri (1986).

$$\alpha_Q = 1,$$
$$\sum_{i=1}^{3} \gamma_{Yi} = 0, \quad \sum_{i=1}^{2} \rho_{Yi} = 0, \quad \alpha_{Yt} = 0, \quad \alpha_{QQ} = 0, \quad \phi_i = 0, \tag{4.22}$$
$$\sum_{i=1}^{2} \phi_{ij} = \sum_{i=1}^{3} \rho_{ij} = \sum_{i=1}^{2} \rho_{it} = 0, \quad \forall_j$$

The model of Canadian agriculture were specified as Cobb-Douglas function to test whether this simpler form was justified by the data.

Table 4.2 Statistics for Test of Hypothesis, Canada.

			Critical Value of χ^2	
	Calculated Value of χ^2	Degrees of Freedom	5% Level	1% Level
Constant Returns to Scale	16.17	1	3.84	6.63
Hicks Neutrality	19.55	6	12.59	16.81
Cobb-Douglas	189.16	16	26.29	31.99
Long-Run Constant Returns to Scale	168.18	12	21.02	26.21
Instantaneous Factor Adjustment, (Hausman).	97.51	9	16.91	21.66

Imposing the restrictions given in equation (4.21) was equivalent to restricting the second-order and interaction terms in equations (4.4) and (4.6) to be zero. The quasi-likelihood ratio (QLR) test proposed by Gallant and Jorgenson (1979), for a system of simultaneous, non-linear, implicit equations with instruments was used to determine the validity of the restrictions. The QLR test is more appropriate for testing restrictions in non-linear simultaneous equation systems than the more

familiar Wald and likelihood ratio tests (LRT) when the hypotheses is of the form

$$\beta = f(g), \tag{4.23}$$

that is where some smaller set of parameters g is contained in a larger set β. The QLR test proposed by Gallant and Jorgenson for application in systems estimated by the NL3SLS estimator is represented by

$$T = n(Q_R - Q_{UR}) \tag{4.24}$$

where Q_R and Q_{UR} are the value of the minimum distance criterion for the null and maintained hypothesis respectively, and n is the number of observations. The formula for the minimum distance function $Q(\beta)$, is

$$Q = (1/n) f(\beta)' (S^{-1} \otimes P_Z) f(\beta) \tag{4.25}$$

where $f(\beta)$ is a vector of stacked residuals from the model, S is a consistent estimate of the covariance matrix of disturbances, held constant across the null and maintained hypothesis and P_Z is the projection or "Hat" matrix of instruments defined by $Z(Z'Z)^{-1}Z'$.

Based on the QLR test, the constant returns to scale hypothesis was rejected at conventional levels of the χ^2 for Canadian agriculture. The critical value of the $\chi^2_{(16)}$ was 26.29 which was exceeded by the calculated value of 189.16 (refer to Table 4.2).

The hypothesis of long-run constant returns to scale was also rejected for Canadian agriculture based on the application of the QLR test. Test results in Table 4.2 indicates that the calculated value of χ^2 of 168.18 exceeded the critical value of 26.21 at the 1% level of significance.

The production technology in Canada was also tested to check whether it was characterized by short-run constant returns to scale. The short-run

constant returns to scale hypothesis suggested the following parametric restrictions,

$$\alpha_Q = 1, \quad \sum_{i=1}^{3} \gamma_{Yi} = 0, \quad \sum_{i=1}^{2} \rho_{Yi} = 0, \quad \alpha_{Yt} = 0, \quad \alpha_{QQ} = 0. \tag{4.26}$$

The results in Table 4.2 indicate that based on the QLR test the calculated value of $\chi^2_{(1)}$ exceeded the critical value of 16.17. Thus the hypothesis that the elasticity of variable cost with respect to output was unity was also rejected for Canadian agriculture.

In addition to the symmetry and homogeneity restrictions imposed on the model to justify aggregation to the sector level, restrictions which imply homotheticity of the production structure were imposed on the model. Homotheticity implies that output is separable from input prices, and that economies of scale (size) can be accurately measured from only an examination of the cost function. The restrictions implied by homotheticity are

$$\sum_{i=1}^{3} \gamma_{Yi} = 0, \quad \sum_{i=1}^{2} \rho_{Yi} = 0, \quad \alpha_{Yt} = 0. \tag{4.27}$$

These restrictions were imposed on the translog cost function and share equations prior to estimation. Technology is Hicks neutral in the sense that it leaves unaltered the ratios of marginal products between pairs of inputs, or equivalently that it does not affect the expansion paths. The restrictions implies by Hicks neutrality are

$$\alpha_{Yt} = \sum_{i=1}^{3} \alpha_{it} = \sum_{i=1}^{2} \rho_{it} = 0 \quad \forall_i. \tag{4.28}$$

Based on the QLR test, the null hypothesis that technical change was neutral in the Hicksian sense was tested and rejected for Canadian agriculture. Table 4.2 indicate that the calculated values of χ^2 exceeded

the critical values at both the 5% and 1% level of significance. The theoretical consistency of the cost function may also be checked via the slope of the input demand functions. A well-behaved cost function will have input demand functions which are negatively sloped. Estimates of the input demand and output supply elasticities are presented in Table 4.3. The estimated own-price elasticity of demand is negative in accordance with theoretical expectations. Model results suggest that the demand for hired labor, energy and intermediate inputs in Canadian agriculture was inelastic.

Table 4.3 Input Demand Elasticities Canada at Geometric Means, 1961-1989.

Component	Intermediate Input	Energy	Hired Labor
Intermediate Inputs	-0.3809 (0.1220)	0.4417 (0.1658)	0.3638 (0.2289)
Energy	0.1240 (0.0466)	-0.9316 (0.1295)	0.1954 (0.0996)
Hired Labor	0.2568 (0.1616)	0.4905 (0.2500)	-0.5592 (0.3127)

[a] Asymptotic standard errors in parentheses.

The estimated standard errors indicate that with the exception of the cross-price elasticity between hired labor and intermediate inputs, all elasticities were statistically significant at the 1% level of significance. Table 4.4 reports values for the Allen partial elasticities of substitution evaluated at the means of the data. These elasticities of substitution were used to evaluate the curvature conditions and are presented for completeness.

Table 4.5 presents estimates of scale economies in Canadian agriculture. The results suggest that the agricultural sector in Canada was characterized by decreasing returns to scale over the 1962-1989 period. Evaluated at the geometric means of the data the returns to scale measure for Canada was .347 and an examination of the asymptotic standard errors indicate that the estimate of returns-to-scale was statistically significant.

United States Model Estimates

The U.S. model was fitted to data for 1961-1989 (refer to Appendix A).[13] The cost function (equation (4.4)), share equations (equation (4.6)) and the profit maximizing condition (equation (4.8)) were estimated as a system with symmetry, homogeneity and homotheticity imposed a priori. The restrictions imposed on the U.S. system reduced the number of parameters to be estimated in the U.S. model to twenty three. The full set of parameter estimates are presented in Table 4.6. Fourteen of the twenty three parameters estimated were statistically different from zero at conventional levels. Based on the adjusted R^2 statistic for individual equations the U.S. model exhibited a fairly good fit. The adjusted R^2 statistics were .903, .876 and .882 for the cost function, the share of intermediate inputs and the energy share equation, respectively. For the profit maximizing condition the adjusted R^2 was .603.

The estimated variable cost function for the U.S. satisfied the regularity conditions of concavity with respect to the prices of variable

[13]Though the U.S model was estimated with data for 1950-1989, only the 1961-1989 sample was used for analysis. In addition to satisfying all the required theoretical requirements at all data points, the 1950-1961 sample yielded elasticities which were statistically significant at the conventional 5% level.

Table 4.4 Allen Elasticities of Substitution, at Geometric Means, Canada, 1961-1989.

Component	Intermediate Input	Energy	Hired Labor
Intermediate Inputs	-0.1583 (0.0388)[a]	0.0313 (0.1379)	0.6939 (0.1189)
Energy		-3.605 (0.6720)	2.0481 (0.4344)
Hired Labor	(symmetric)		-4.3679 (0.4758)

[a] Asymptotic standard errors in parentheses.

Table 4.5 Returns To Scale, Canada, 1962-1989.

Returns To Scale (∂ln C/∂lnQ)	
Year	Canada
1962-1966	0.285
1967-1971	0.281
1972-1976	0.304
1977-1981	0.364
1982-1986	0.447
1987-1989	0.432
Mean	0.347 (0.164)[a]

[a] Asymptotic standard error in parentheses.

inputs and of convexity in respect to the level of the quasi-fixed factors.[14] Concavity was satisfied at each sample point and convexity was checked and accepted at most sample points and at the geometric means of the data.[15]

A test for the appropriateness of specifying technology by a variable cost function with capital and labor as quasi-fixed in the U.S. agricultural sector was performed. Application of the test given by equation (4.20) supported the hypothesis that the characterization of technology as including some degree of fixity was justified for the model of U.S. agriculture. The test results in Table 4.7 indicate that the calculated value of the test statistic of 97.51 exceeded the critical $\chi^2_{(9)}$ value of 19.67. Thus the null hypothesis of equality between the observed market prices and their respective shadow values for operator-family labor and capital inputs in U.S. agriculture was rejected

The U.S. model was also specified as a Cobb-Douglas function in order to test whether this simpler form was justified by the data. This was done by imposing the restrictions given in equation (4.21), which is equivalent to restricting the second-order and interaction terms in equations (4.4) and (4.6) to zero. The Gallant and Jorgenson QLR test for a system of simultaneous non-linear equations estimated with instruments was used to determine the validity of the restrictions.

---

[14]Similar to the Canadian model the share equation for hired labor was omitted to maintain theoretical consistency with a priori restrictions imposed on the model.

[15]In the U.S model twenty of the twenty-nine parameters had the correct sign for quasi-fixed labor while eighteen exhibited the correct sign for quasi-fixed capital, when evaluated at the first derivative with respect to the cost function.

Table 4.6 Parameter Estimates for Translog Variable Cost Model, United States, 1961-1989.

Parameter	Estimate	Parameter	Estimate
	United States		
α_0	-400.958 (381.924)[a]	ρ_{11}	-0.110 (0.029)
α_Q	9.016 (0.933)	ρ_{12}	0.095 (0.017)
α_{QQ}	-0.605 (0.081)	ρ_{21}	0.041 (0.017)
β_1	1.439 (0.370)	ρ_{22}	0.032 (0.009)
β_2	-1.236 (0.230)	α_t	-0.640 (4.539)
γ_{11}	0.108 (0.021)	α_{tt}	0.207 (0.013)
γ_{22}	0.054 (0.006)	α_{1t}	-0.002 (0.001)
γ_{12}	-0.710 (0.010)	α_{2t}	0.005 (0.0006)
ϕ_1	32.144 (31.629)	ρ_{1t}	0.068 (0.441)
ϕ_2	34.148 (48.629)	ρ_{2t}	-0.013 (0.113)
ϕ_{11}	-0.893 (2.236)	δ_0	N.E
ϕ_{22}	-0.990 (4.344)	δ_1	N.E
ϕ_{12}	-2.204 (4.44)	δ_2	N.E

[a] Asymptotic standard errors in parentheses
N.E: Not estimated as demand function was not part of United States model.

Table 4.7 Statistics for Test of Hypothesis, United States.

	Calculated Value of χ^2	Degrees of Freedom	Critical Value of χ^2 5% Level	1% Level
Constant Returns to Scale	57.73	1	3.84	6.63
Hicks Neutrality	27.52	6	12.59	16.81
Cobb-Douglas	229.86	16	26.29	31.99
Long-Run Constant Returns to Scale	192.69	12	21.02	26.21
Instantaneous Factor Adjustment, (Hausman).	86.48	9	16.91	21.66

The hypothesis that the coefficients of the cross-product terms were all zero was rejected at conventional levels of the χ^2, for the U.S. model. According to the results of the test reported in Table 4.7 the critical value of the $\chi^2_{(16)}$ was 26.29 which was exceeded by the calculated values of 229.86. Hence it is fair to conclude that the production structure in the U.S. and did not exhibit characteristics consistent with a Cobb-Douglas structure and that the elasticity of factor substitution was not constant and equal to one.

The theoretical consistency of the cost function was also assessed via the slope of the input demand functions. As previously indicated a well-behaved cost function will have input demand functions which are negatively sloped. Estimates of the input demand and output supply elasticities are presented in Table 4.8. The estimated own-price

elasticity of demand was negative in accordance with theoretical expectations. The own-price elasticities of demand for energy, hired labor and intermediate inputs in the U.S. were less than one, i.e the factor demands were inelastic.

Table 4.8. Compensated Output Supply and Input Demand Elasticities United States at Geometric Means, 1961-1989.

Component	Output	Intermediate Input	Energy	Hired Labor
Output	1.32 (0.0689)[a]	0.4418 (0.0395)	-0.1956 (0.0395)	-0.313 (0.0395)
Intermediate Inputs	2.709 (0.986)	-0.1167 (0.028)	0.0230 (0.102)	0.5114 (0.0876)
Energy	2.709 (0.986)	0.0031 (0.0313)	-0.358 (0.671)	0.2035 (0.0432)
Hired Labor	2.709 (0.986)	0.1135 (0.0194)	0.3352 (0.0711)	-0.7149 (0.0778)

[a] Asymptotic standard errors in parentheses.

The estimated standard errors indicate that with the exception of the cross-price elasticity between energy and intermediate inputs, all other elasticities were statistically significant at conventional levels. Table. 4.9 reports values for the Allen partial elasticities of substitution evaluated at the means of the data. These elasticities were used in the assessment of curvature conditions in the model and are presented for completeness.

The elasticity of supply was positive in accordance with theoretical expectation and the estimated standard errors were small relative to the size of the parameter values. The results revealed that the supply

elasticity in U.S. agriculture was elastic (1.32) and statistically significant at the 1% level of significance.

Table 4.9 Allen Elasticities of Substitution, United States at Geometric Means, 1961-1989.

Component	Intermediate Input	Energy	Hired Labor
Intermediate Inputs	-0.7570 (0.2425)[a]	0.8765 (0.3296)	0.7230 (0.4550)
Energy		-6.581 (.9162)	1.3807 (0.7038)
Hired Labor	(symmetric)		-1.5740 (0.8804)

[a] Asymptotic standard errors in parentheses.

The hypothesis that the elasticity of cost with respect to output was unity was tested in the U.S. model by testing the validity of the restrictions represented by equation (4.26). According to the results of the QLR test reported in Table 4.7, the calculated value of 57.73 exceeded the critical value of $\chi^2_{(1)}$ leading to a rejection of the unitary cost-output elasticity hypothesis for aggregate U.S. agriculture. The long-run constant returns to scale hypothesis was also rejected in the U.S. model. Based on the QLR test, the calculated value of 192.69 exceeded the critical value of χ^2 at the 1% level of significance, (refer to Table 4.7). This led to a strong rejection of the long-run constant returns to scale hypothesis as characterizing technology in the U.S. agricultural sector.

Based on the QLR test, the null hypothesis that technical change was neutral in the Hicksian sense was tested and rejected for U.S. agriculture. Table 4.7 indicate that the calculated value of χ^2 exceeded

the critical values at both the 5% and 1% level of significance. Hence, it is reasonable to conclude that technical change in the U.S. has been an important factor and that it has been of a non-neutral nature.

Estimates of scale economies presented in Table 4.10 suggest that the agriculture in the U.S. was characterized by decreasing returns to scale. The measure of returns to scale evaluated at the geometric means of the data indicate that the returns to scale measure for the U.S. was .489 and was statistically significant over the 1961-1989 period.

Though not directly related to the bilateral competitiveness index, the relative importance of technical change in TFP growth is also of interest for at least two reasons. The first is that as indicated throughout the study, only in the case of constant returns to scale is the rate of technical change equivalent to the rate of growth of TFP. The rejection of constant returns to scale and the subsequent finding that technology in the U.S. and Canada exhibits diminishing returns to scale justifies the decomposition suggested by equation (3.21). Once technical change (TFP) is estimated, TFP (technical change) is determined. The manner in which it is determined is given by equation (3.21).

The second reason for interest in TFP is that it facilitates a more direct means of comparing the results of this study with the results of other econometric studies on the structure of U.S. and Canadian agriculture. In all cases where such comparisons are made, the studies utilize econometrics as the empirical tool and proceeds with TFP decomposition in a manner totally consistent with the decomposition pursued here.

The results of the decomposition are reported in Table 4.11 for Canada and Table 4.12 for the U.S. According to the tables, decreasing returns to scale in U.S. and Canadian agriculture contributed to increases in variable cost and hence to reductions in the rate of TFP growth.

Table 4.10 Returns To Scale, United States, 1962-1989.

Returns To Scale ($\partial \ln C/\partial \ln Q$)	
Year	United States
1962-1966	0.473
1967-1971	0.486
1972-1976	0.503
1977-1981	0.526
1982-1986	0.537
1987-1989	0.544
Mean	0.490 (0.014)

[a] Asymptotic standard error in parentheses.

The aggregate price effect captures the effect of increases in the price of variable inputs and the level of quasi-fixed labor and capital on TFP growth. In general, increases in variable input prices will increase variable costs and reduce TFP growth. Increases in the level of quasi-fixed inputs, on the other hand, causes variable costs to decline and the rate of TFP growth to increase. Changes in both variable input prices and the level of quasi-fixed inputs are weighted by differences in their respective observed and shadow cost shares. It is the cumulative impact of these changes that is captured by the aggregate price effect.

Table 4.11 Decomposition of TFP Growth, Canada, 1962-1989.

		Estimated Source of TFP Growth, (%).		
Period	Average Annual TFP Growth	Nonconstant Returns to Scale	Technical Change	Aggregate Price Effect
1962-1966	1.439	-6.130	6.700	0.868
1967-1971	1.415	-4.644	5.519	0.540
1972-1976	4.697	1.777	3.062	-0.142
1977-1981	-0.623	-0.794	0.218	-0.047
1982-1986	-0.376	-0.136	-0.182	-0.055
1987-1989	-0.049	0.039	-0.030	-0.058
1962-1989	1.118	-1.462	2.520	0.053

Table 4.12 Decomposition of TFP Growth, United States, 1962-1989.

		Estimated Source of TFP Growth, (%).		
Period	Average Annual TFP Growth (%)	Nonconstant Returns to Scale	Technical Change	Aggregate Price Effect
1962-1966	1.154	-1.740	2.906	-0.012
1967-1971	0.725	-2.820	3.525	0.020
1972-1976	1.139	-2.569	3.750	-0.041
1977-1981	1.713	-2.193	3.898	0.009
1982-1986	2.638	-1.484	4.166	-0.044
1987-1989	2.500	-1.882	4.355	0.028
1962-1989	1.584	-2.130	3.720	0.006

With the exception of the 1982-1989 period in Canada, the agricultural sectors in both the U.S. and Canada experienced cost-reducing technical change. Table 4.11 indicates that the rate of technical change in Canada during the 1962-1989 period, was approximately 2.52% per annum. In the U.S. over the same period, the average annual rate of technical change was 3.72%. Over the entire 1962 to 1989 period, the rate of technical change accounted for the majority of TFP growth in both U.S. and Canadian agriculture. The increase in TFP growth was, however, countered by the scale effect, which contributed negatively to TFP growth. The aggregate price effect impacted TFP growth positively in both countries, though its contribution was negligible.

The results of the decomposition indicate that two periods can be distinguished based on the pattern of TFP growth. From 1962-1972, the rate of growth in TFP was greater in Canadian than in U.S. agriculture. The rates of growth in Canada were 1.427% for the 1962-1971 period and 4.70% for the 1972-1976 sub-period, whereas growth rates in the U.S. for the corresponding period were 0.725% and 1.139%, respectively. In the post-1976 period, the rate of growth of TFP in Canada was negative, averaging -0.495 over the 1977-1989 sub-period, while the rate of growth of TFP in the U.S. continued to increase steadily, averaging 2.50% over the same period. For the 1962 to 1989 period, the rate of TFP growth in the U.S. was 1.58%, while the rate of TFP growth in Canada for the corresponding period averaged 1.118% per annum.

Comparisons with Other Studies

Several studies have been undertaken on the structure of U.S and Canadian agriculture.[16] However, because of differences in methodologies, coverage periods, etc., direct comparison of the results of these studies must be carefully undertaken to avoid spurious and misleading conclusions. Notwithstanding this, the results obtained here will be compared to those of earlier studies by Binswanger (1974) and Ray (1982) since these studies were among the first to apply duality theory to agriculture. In addition the results of the present study will be compared to that of a number of more recent studies undertaken on the structure of U.S. and Canadian agriculture.

U.S. Estimates of Returns to Scale

Ray (1982) utilized a multiple-output, five input translog cost function in the analysis of U.S. agriculture between 1939-1977. Based on an F-Test, Ray rejected constant returns to scale for U.S. agriculture. His results suggested that the technology was more appropriately characterized by decreasing returns to scale. The magnitudes of the scale economies differ between the present study and those obtained in Ray (1982). This is partly attributable to the structural differences in his model and the one specified in this paper.[17] Ray's model was for a joint output, Hicks-neutral, non-homothetic technology. This is in sharp contrast to the single output model adopted here which rejects Hicks neutrality and maintains homotheticity as a necessary theoretically

[16]See Capalbo and Antle (1988) for an excellent review of such studies.

[17]Scale economies in Ray (1982) ranged from .635-.834.

assumption for aggregation. Capalbo (1988) estimated a two output three input translog cost function for U.S. agriculture from 1950-1982. Capalbo also finds evidence of decreasing returns in U.S. agriculture.[18] The results of the studies by both Capalbo and Ray are consistent with the findings of this study which indicate that U.S. agriculture between 1961-1989 was characterized by decreasing returns to scale.

U.S. Estimates of Input Demand Elasticities

In the study by Ray, labor was found to be most responsive to changes in its own price, the value of the elasticity of demand for hired labor was -.8389. This was followed by the own-price elasticity of intermediate inputs which ranged from -.1275 to -.3905. Though slightly higher than the magnitudes of the elasticities obtained in this study, the elasticities obtained by Ray and those presented in Table 4.8 are quite consistent with each other. Capalbo's study is specifically concerned with the measurement of aggregate productivity growth in U.S. agriculture and factor-price elasticities are not reported as part of the output.

Binswanger (1974) estimated a single output translog function for U.S. agriculture, using pooled cross-sectional and time series data for the years 1949, 1954, 1959, 1964. He estimated only the share equations and derived the remaining parameters of the cost function from them.[19]

---

[18]The model developed by Capalbo (1988) is quite similar to the one developed here. However while the estimator employed here is non-linear three stage least squares (NL3SLS) with instruments, on account of the endogeniety of output. Capalbo is forced to adopt 3SLS, due to data limitations. In addition the cost function is specified in joint-outputs (crops, livestock) with coverage from 1950-1982.

[19]When the share equations alone are estimated, some parameters of the cost function cannot be retrieved.

Binswanger finds the own-elasticity of demand for labor to be -.9109, which is somewhat larger than the -.7149 estimate in this study. In addition he finds fertilizer and labor to be complements, a conclusion which seemed surprising to Ray (1982). Ray's findings which suggest substitutability between all pairs of inputs are consistent with those of this study. Brown and Christensen (1981) estimated a single-output, five input translog restricted cost function, using annual time series data for 1947-1974. They found an own-price elasticity of demand for materials ranging from -.188 to -.198; this is somewhat larger than the value for the corresponding elasticity obtained in this study. This difference seems to be due to the inclusion of energy inputs in the material input category by Brown and Christensen. They also found the demand for hired labor to be inelastic, at the geometric mean of the data the magnitude of this elasticity was -.66. This estimate is in the range of the own-price elasticity estimate for hired labor obtained in this study.

U.S. Estimates of the Elasticity of Supply

Ball (1988) approximated a restricted profit function with the translog approximation in the analysis of U.S. agriculture between 1948-1979. An appropriately weighted average of Ball's estimates of the supply elasticities for crops and livestock (1.110 and 1.089, respectively) was within the range of the 1.32 estimate obtained in this study.[20] The results of the factor price elasticities obtained in the Ball study are however, not directly comparable with those presented here. This is

[20]Ball employed a multiple-output framework, while crops and livestock are aggregated in a single output in this study. In addition, Ball treats durable equipment, real estate and farm produced durable separately, in this study they are aggregated together into a measure of capital.

because the study by Ball presents uncompensated or Marshallian elasticities while the elasticities presented here are of the Hicksian or compensated form. Hypothetically, since this study models output as an endogenous choice variable, uncompensated or Marshallian elasticities could have been calculated. However other considerations dictated the presentation of the compensated elasticities given in Table 4.8.

U.S. Estimates of Technical Change

With regard to technical change the findings of this study are also consistent with the findings of Ray and Capalbo. Ray found technical change to be occurring at the rate of 1.8% annually. In contrast this study found the rate of technical change to be 2.29% per annum between 1950-1989. In the study by Capalbo the rate of technical change was found to be approximately 1.75% per annum between 1950-1982. Again this finding is generally in the range of the estimate obtained in this study. The trend in technical change was also the same in both the present study and the study by Capalbo, giving credence to the findings that generally the decade of the 1970's witnessed relatively higher per annum growth than the decade of the 1960's. In the study by Brown and Christensen, the rate of technical progress was found to be negative (technological regression); according to Capalbo and Antle, this is but one of the irregularities of the Brown and Christensen study.

Canadian Estimates of Returns to Scale

A comparison of the estimates of this study with that of other studies undertaken on the structure of Canadian agriculture also suggests general consistency among the results. In developing a number of models for Canadian agriculture, Islam (1982) estimated several variants of the

translog cost function, using data from 1961-1978. Besides concluding that the Cobb-Douglas was inappropriate as a characterization of Canadian agriculture, Islam's also found that technology in Canadian agriculture exhibited decreasing returns to scale.

Canadian Estimates of Input Demand Elasticities

The elasticity of demand for labor in the study by Islam is, however, not directly comparable with the estimates obtained in this study since Islam categorizes labor as inclusive of family and operator labor. In this study, only hired labor is included in variable inputs. Similar considerations prevent direct comparisons of the demand for intermediate inputs. The elasticity of demand for energy in the Islam study of -.975 is, however consistent with the -.931 estimate obtained in this study.[21] Islam also finds substitutability between all pairs of inputs for aggregate Canadian agriculture.

Lopez (1984) estimated a Generalized Leontief approximation to the restricted profit function for Canadian agriculture using cross-sectional data for 1971. With the exception of adopting a joint-output (crops and animal products) specification and the fact that energy is not treated as a separate input, the classification of inputs are quite similar to that of this study.[22] While both compensated and uncompensated elasticities are presented in the Lopez study, for reasons previously cited comparisons will be only undertaken with the compensated elasticity estimates. Lopez found that the own-price elasticity of demand for the hired labor to be

[21]Energy is defined in a similar manner in this study as in the study by Islam.

[22]Lopez (1984) also treated capital, land and structures and operator and family labor as separate but variable factors of production.

inelastic, with a value at the mean of -.337. This is somewhat lower than the -.559 estimate at the mean obtained in this study.

Lopez (1980) estimated a Generalized Leontief approximation to the cost function for Canadian agriculture using annual time series data for the period 1946-1977. Data definitions were similar though not identical to those of this study, but hired labor and energy were not classified as separate inputs and all factors were assumed variable. Lopez (1980) also found the own-price elasticity of demand for intermediate-inputs to be inelastic (-.410) and that all pairs of inputs exhibited substitutability.[23]

Lopez et al. (1982) investigated the substitution possibilities between energy and non-energy inputs in Canadian agriculture between 1961-1979. Comparison between the elasticities of substitution in Lopez (1982) and those of this study, indicate that the elasticities are identical in sign, though some variations exists in magnitude. In addition to the finding that all pairs of inputs were substitutes, the own-price elasticity of energy was found to be -.392. This estimate is particularly low because it covers the era of cheap energy in Canada, subsequent sharp increases in energy prices captured in this study would most certainly have radically altered the magnitude of this elasticity. Due to differences in the definition of intermediate inputs between the present study and the study by Lopez, a comparison of the own-price elasticity was not possible. Though the own-price elasticity of demand for hired labor was inelastic in both studies, the magnitudes differed somewhat. While

[23]Lopez (1984) also found that all pairs of inputs exhibited substitutability.

Lopez et al. (1982) reports a value of -.397, the estimate from the present study suggests an own-price elasticity of demand for labor of -.559. The results of the study by Lopez et al. (1982) must, however, be interpreted carefully, as approximately one-half of the parameters are statistically insignificant at the 5% level. In addition, the model is not well-behaved, since the marginal cost is negative and the supply function negatively sloped.[24]

Canadian Estimates of Technical Change

Lopez (1980) also tested and rejected the hypotheses of constant returns to scale for Canadian agriculture. Lopez argued that the acceptance of neutral technical change was due to the non-homotheticity assumption maintained in his study. He further argued that if the restrictions implying homotheticity were imposed then the technology would exhibit non-neutral technical change. Since homotheticity was imposed in this study for Canadian agriculture and technical change was found to be both important and non-neutral, Lopez's arguments seem convincing. Lopez's (1980) conclusions also supported the finding of this study that the Cobb-Douglas specification appeared inappropriate for characterizing Canadian agriculture. Islam in his study of Canadian agriculture also found evidence of non-neutral technical change.

[24] Lopez (1982), apparently experienced some of the same difficulties encountered in specification (with regard to the negativity of marginal cost and the elasticity of supply) as initially experienced in the current research. In fact, he suggests but does not implement two possible ways of overcoming this problem. He recognized that relaxing the assumption of competitive product markets was one way of amending this impasse. As outlined in the model specification section this is the assumption adopted here.

Both from the analysis of the U.S. and Canadian models, and from their general consistency with previous research, the specification and implied results of the models of the U.S. and Canadian agricultural sector seem reasonable. In addition, both model specifications were consistent with theoretical regularity conditions and with the assumptions imposed on the technology.

CHAPTER V
ANALYSIS

In this chapter the estimated bilateral competitiveness index is presented and discussed. In section one, the pattern of bilateral agricultural competitiveness between Canada and the U.S over the 1961-1989 period based on the index is examined. This section also compares inferences based on the estimated competitiveness index with other indices of bilateral competitiveness between the U.S and Canada.

In section two the consistency of the estimated index with historical events in the agricultural sectors of the U.S and Canada and with previous studies is undertaken. The role of government policy through domestic agricultural and trade policies and its impact on bilateral competitiveness is also discussed. Interest lies in the manner and extent to which such factors are captured by the estimated index. Since this model does not allow for endogenous government policy formation, no causal relationships can be established. The discussion is therefore limited to the apparent impacts of policy on the index and is supported where possible by the results of previous research.

The chapter concludes with an investigation of the various factors which affect the index along with an examination of their relative importance. Specifically the role of differential rates of growth in technical change, relative rates of growth in aggregate output price, the relative rate of growth in variable input prices, exchange rates and scale

economies in the determination of changes in the competitiveness gap are examined.

Trends in Competitiveness

Table 5.1 reports average returns per unit of quasi-fixed factors in U.S and Canadian agriculture. Average returns per unit of quasi-fixed resource declined in both the U.S and Canada between 1961-1989. The decline was however more pronounced in Canadian than in U.S agriculture.

The 1960-1970 period was the most profitable for Canadian agriculture (Table 5.1). Between 1962-1966 returns to quasi-fixed factors averaged U.S $1.172. While average returns per unit of quasi-fixed resource declined moderately over the 1972-1976 period, in the post-1976 period the decline in per unit returns to quasi-fixed factors in Canadian agriculture was sharp.

For U.S agriculture the most profitable period was the decade of the 1970s. During the 1972-1976 period, average per unit returns to quasi-fixed resources in U.S. agriculture, was U.S $1.16. In the post-1981 period however, the rate of return to quasi-fixed factors in U.S agriculture declined substantially. Over the 1987-1989 period the average rate of return declined to U.S $0.4844 per unit of quasi-fixed resource in U.S agriculture.

The U.S was more competitive than Canada in 1961, (MIC>1). In 1962, however, the competitive advantage shifted in favor of Canada and against the U.S, (MIC<1).[1]

[1]The U.S has a competitive advantage in agriculture if MIC>1. When MIC<1, Canada has a competitive advantage or conversely, the U.S has the competitive disadvantage in agriculture.

Table 5.1 Competitive Advantage United States and Canada, 1961-1989.

	Average Per Unit Returns to Quasi-Fixed Factors (U.S Dollars).		
Period	Canada	United States	Ratio (U.S/Can)
1961	0.8521	1.1463	1.3450
1962-1966	1.1723	1.0666	0.9121
1967-1971	1.0570	0.9997	0.9445
1972-1976	0.8160	1.1630	1.4558
1977-1981	0.5590	1.1781	2.0561
1982-1986	0.3466	0.5394	1.5670
1987-1989	0.3091	0.4844	1.5917

Figure 5.1 indicates that the gap in competitiveness widened between the two countries between 1962-1966. However from 1967 the U.S began to close the gap, such that by 1971, the gap in competitiveness between the two countries was virtually insignificant. The competitive advantage again shifted to favor the U.S in 1972, fuelled by the steady growth in profits experienced by U.S agriculture in the latter part of the 1960s.[2] By 1972 a small gap in competitiveness had developed in the U.S's favor. The competitive advantage exhibited by U.S agriculture from 1972 was consolidated in the decade of the 1970s. By 1978-79 the MIC exceeded 2.00 for the first time since 1961, indicative of the decisive competitive edge possessed by U.S agricultural producing industries.

[2]For ease of discussion the more familiar value added term will be used in preference to restricted profits in the remainder of this chapter.

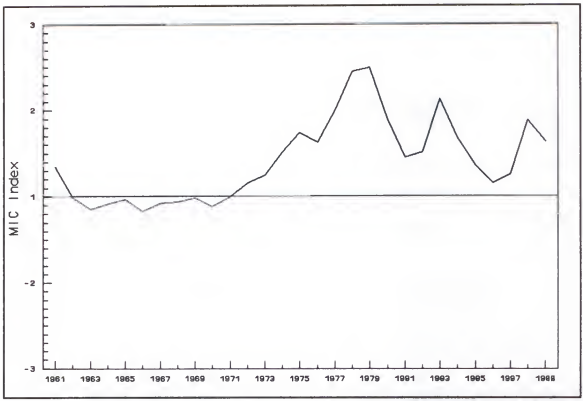

Fig. 5.1 Bilateral Index of Agricultural Competitiveness, United States and Canada, 1961-1989.

The competitiveness of Canadian agriculture deteriorated significantly over the 1977-1981 period, as evidenced by per unit returns to quasi-fixed factors which declined to 0.5 for the first time since 1961. The U.S's competitiveness gap with Canada narrowed between 1980-1982; however, this was due more to diminishing per unit returns to quasi-fixed factors in the U.S than to a turn-around in Canadian agriculture. By 1983 however, the U.S's competitive position had rebounded to its 1978-79 level and has remained strong since.

Figure 5.2 shows the trend in annual value added for the U.S and Canadian agriculture derived from the parameters of the restricted profit function. The value added index indicates the same pattern of competitiveness as the data representing average per unit returns to

quasi-fixed factors in Table 5.1. This is because the data on which Figure 5.2 is based are the individual value added indices for the U.S and Canada on which the competitiveness index (MIC), in Table 5.1 is based.

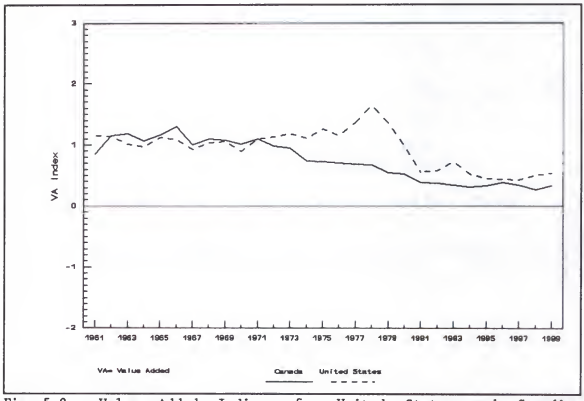

Fig. 5.2 Value Added Indices for United States and Canadian Agriculture, 1961-1989.

The value added index shows that the U.S was more competitive than Canada in 1961; that between 1962-1971 Canada was more competitive than the U.S; and that the U.S was more competitive than Canada from 1972 to 1989. Table 5.2 reports the annual rates of change in value added (VA) for the U.S and Canada, derived from the parameters of the restricted profit function. Table 5.2 differs in interpretation from Table 5.1 in that it reports average annual rates of change in value added, facilitating a more direct analysis of changes in the competitiveness gap between the two

countries. Table 5.2 suggests that while the competitiveness of Canadian agriculture was reinforced by a positive rate of growth in value added (RGVA) over the 1962-1971 period, such was not the case over the 1972-1976 period.

Table 5.2 also indicates that between 1967 and 1971, the U.S had begun to narrow the competitiveness gap even though Canada still possessed an overall competitive advantage. Table 5.2 column 2 suggests that this was mainly due to the strong performance in the U.S, but was also supported by a slowdown in the RGVA recorded by Canadian agriculture (column 1). Taken together, these findings suggest that the U.S began to catch-up and Canada to slow down by 1967. It was not however until 1972 that the competitive advantage of the Canadian agricultural sector was surpassed by that of its U.S counterpart.

Table 5.2 Annual Rates of Change in Value Added United States and Canada, 1961-1989.

	Annual Rates of Change in Value Added (%)		
Period	Canada	United States	$RGVA_{U.S,Can}$
1962-1966	5.197	2.496	-2.701
1967-1971	1.845	3.703	1.858
1972-1976	-2.029	4.396	6.425
1977-1981	1.552	3.598	2.046
1982-1986	0.306	0.829	0.523
1987-1989	-3.786	3.184	6.970

According to the Table 5.2, the competitiveness of Canadian agriculture as evidenced by the RGVA deteriorated considerably more in the 1972-1976 period than had been the case previously. This, coupled with the continued strong performance on the part of U.S agriculture reflected in the rate of change in value added of 4.396%, proved sufficient to cause a switch in competitive advantage to favor the U.S over the 1971-1976 period. Though the RGVA had again turned positive in Canada over the two subsequent sub-periods, this failed to be sufficient to recapture the competitive advantage in agriculture lost to the U.S in the early 70s.

Over the 1982-1986 sub-period, Canada narrowed its gap with the U.S, due in part to a slight downturn of RGVA in U.S agriculture; however, the competitive advantage still remained decisively in the U.S's favor, (refer to Figure 5.2). This turn-around in Canadian agriculture was, however, short-lived as the RGVA in that country again turned negative in the period between 1987 and 1989. In fact this performance by Canada was the weakest of the entire 1961-1989 period. Concurrently, recovery by the agricultural sector in the U.S as evidenced by the positive RGVA resulted in the continued competitive advantage of U.S agriculture.

MIC and Historical Trends in Trade and Production

In order to assess the credibility of the MIC as a bona fide measure of competitiveness, its ability to reflect the historical impacts in addition to the effects of relative changes in trade and domestic government policy on the structure of production will be assessed. Specifically, the task which presently confronts the study is to explain the initial competitive advantage of U.S agriculture in 1961, along with the switch which occurred in 1972. In addition the noticeable increases in

the estimated index in 1978-79 and again in 1983 must also be explained in terms of observed differences in historical trade and production trends between U.S and Canadian agriculture.

The MIC in 1961 appears to be consistent with the low production and exports in Canada in that year. Production in 1961 was 18% less than the preceding year and 22% less than in 1962. While there were no dramatic occurrences in U.S agriculture in 1961, the steady growth experienced in the 1950s was sustained throughout the 1960s.

As a country with a moderately sized domestic market, Canada has always been heavily dependent on trade. Over the 1962-1967 sub-period, Canadian exports to the European Economic Community (EEC), the principal market for Canadian agricultural exports, increased steadily. The U.S and Japanese markets were also important for Canadian exports. Grain exports in Canada accounted for over 80% of total agricultural exports prior to 1973, a significant proportion of which was composed of wheat exports (85% between 1964-1968) (OECD, 1978). Declining wheat prices from 1968 had, however, begun to reverse the favorable trade balance previously enjoyed by Canada. By 1970 wheat prices adjusted for inflation had declined to CAN $190.49 per tonne, down from CAN $274.33 per tonne at the end of 1965. Wheat prices declined even further in 1971-72 reaching $176.75 per tonne at the end of 1972. This led to a slight decline in total receipts to Canadian agriculture for the 1967-1971 sub-period. This situation was further aggravated by unusually low wheat exports in 1969. In the U.S. on the other hand, the more diversified nature of agricultural production, the larger domestic market and the relatively smaller proportion of production exported enabled prices received by producers to decline

relatively less than in Canada.[3] These occurrences are consistent with the behavior of the estimated index, which indicated that although the U.S had begun to catch-up during the 1967-1971 period, over the entire 1962-1971 period Canada continued to possess the overall competitive advantage in agriculture.

The policy environment under which industries operate has direct implications for international competitiveness. Indeed, if the MIC provides a credible measure of competitiveness, there should be an association between changes in the index and domestic production and trade policies. While no causal relationship can be established, and no such claim is made, it is reasonable to expect policy responses to perceived changes in competitiveness.

It has become well accepted that international trade in agricultural commodities is influenced in large measure by national agricultural policies. Josling et al. (1990), contends that,

> International trade in farm products is shaped by the interaction of national agricultural policies. In developed countries these policies characteristically stimulate agricultural output and discourage consumption, thereby reducing net import requirements and increasing net export availability. International trade flows are distorted and destabilized by such policies; trade becomes a balancing mechanism for policy-determined deficits and surpluses.(p. 433).

Perhaps the single most distinctive feature between policies in the U.S and Canada is the fact that policies in the U.S are national with individual states having relatively little clout, whereas in Canada, the provincial governments are instrumental in the formulation and initiation

---

[3]Oleson (1987) points out that in the U.S export revenues accounted for only 20% of the value of grain production and 47.5% of the value of wheat production prior to 1970.

of farm programs. Government policies in Canada through the Canadian Agricultural Stabilization Act (ASA) support nine commodities. These are beef cattle, hogs, sheep and lamb, industrial milk and cream, corn, soybean, wheat, oats and barley grown outside the designated area of the Canadian Wheat board. In sharp contrast to the federal ASA programs, the programs of the provincial governments are instituted with little consideration of their impacts on international trade (Meilke and Warley, 1990).

In the U.S. the rationalization for farm support is similar to that used in Canada: to ensure stability of farm income and retain family farms. In the U.S. programs exist for wheat, feed grain, cotton, dairy products, sugar, rice, peanuts, tobacco and wool.

Blandford (1990) shows that direct government expenditure as a percentage of agricultural value-added was 14 percent for both Canada and the U.S in the late 1970s.[4] His findings suggested that the U.S devoted the largest proportion of its agricultural expenditures to supporting the price of commodities such as grain, cotton, and dairy products through government purchases.

The 1970s marked a new era for U.S agriculture. In contrast to the steady growth of the 1960s, the 1970s witnessed rapid growth in exports along with changes in the composition of its exports. Meekhof (1979), points out that the volume of agricultural exports increased by 77% and domestic demand by 10% between 1967 and 1977. Land used for crop

---

[4]While the U.S supported wheat, corn and sugar producers more than Canada supported its producers of these commodities, Canada supported dairy and poultry producers more heavily than the U.S did their producers of these commodities.

production in the U.S also expanded by 9.5% between 1968 and 1978. Spurred by growth in world demand and income, world trade nearly quadrupled and the U.S's share of world agricultural trade increased by 4%. The value of U.S exports increased six-fold between 1971-72 and 1980. The emergence of the Soviet Union as a major purchaser of grain after 1973 and the PL 480 program, which gave credit to developing countries for food purchases, also assisted in this expansion. In terms of changes in the structure of trade, food, feed grains and livestock products accounted for 70% of agricultural trade in the 1970s, an increase of 47% over the previous decade.

The impetus which U.S agriculture received from the expansion was greater than that of Canada. In response to the world food crisis and the OPEC oil price increases of 1972-1974, the demand for wheat, corn, and soybeans increased markedly. In the U.S between 1967 and 1971 exports of wheat, corn and soybeans increased 10%, 15%, and 9% respectively, (Meekhof, 1979). The fact that both production and exports seemed to have increased more in the U.S than in Canada is due in part to the larger magnitude of the elasticity of supply in the U.S (1.32) than in Canada (0.417) reported earlier in this study. Considered together, these developments seem to give credence to the changes in competitiveness that occurred between the 1972-1976 and the 1977-1981 periods.

The observed peaks in the index in 1978 and again in 1979 appear to be related to a decline in aggregate output in Canada, again induced by drought. The output index for Canada declined by 10.25% between 1978 and 1979 and did not rebound to its long-term average until 1981. The peak in the index of 2.49 in 1979 with subsequent declines to 1.88 in 1980 and

1.45 in 1981, seem consistent with this explanation. According to the bilateral index the U.S's competitive advantage was greatest in the 1970s, peaking in 1979.

The 1981-1986 sub-period however was marked by the persistent erosion of the U.S's competitive edge, due partly to steadily declining grain and wheat exports. The decline experienced in bulk commodities was further aggravated by the financial crisis which began affecting U.S agriculture.

The 1980s ushered in a new era for policy reform in both the U.S and Canada. Commenting on the implications for Canadian agricultural policy, Meilke and Warley argue that it became shaped by the policy of others and that

> the agricultural euphoria of the 1970s that led policy makers to embrace a strategy for growth was followed abruptly by considerations of survival and adjustment in the difficult economic environment of the 1980s. (p.113).

Gardner in reviewing the evolution of farm policy in the U.S was of the view that

> the problem in the 1980s was the large build up of commodity stocks that resulted from the weakening of the strong markets of the 1970s. (p. 21).

The restrictive monetary policies instituted by the U.S increased real interest rates and contributed to a sharp appreciation of the U.S dollar against other major currencies. The financial crisis was rooted in the rapid pace of borrowing and investment which occurred in the 1970s. The global recession in 1981, however, caused nominal interest rates to exceed 20% in some cases. The high cost of borrowing also reduced aggregate demand in the debt-ridden developing countries. In addition the EEC had become a major competitor in world agricultural trade by the

1980s, along with other countries such as China and India which had changed their status from net-importers to net-exporters of grain. Concurrent with this was the weakening of agricultural commodity prices. Meilke and Warley (1990) posit that the impact of this was devaluation of agricultural land values and cash flow problems for producers holding too much debt.

In the U.S, the Federal Reserve moved to institute restrictive monetary policy which led to a rise in real interest rates. Macro-economic conditions in Canada being sensitive to conditions in the U.S responded to the changes. Interest rates in Canada were increased to prevent capital out-flows to the U.S and the Canadian dollar was allowed to depreciate against the U.S dollar, (Freshwater, 1987).

The impact of the U.S farm crisis on the farm sector in Canada was somewhat delayed due to the long-term contracts existing for some export commodities and the domestic stabilization programs already in existence. In addition most of the world commodity prices were negotiated in U.S dollars, thus the depreciation of the Canadian dollar mitigated the immediate negative impacts of the crisis on farm receipts.

Another reason for the more immediate effects in the U.S relates to the structure of the industries in both countries. In the U.S small farms constitute a much larger percentage of all agri-producing units than in Canada. This led to more immediate collapses in the U.S, since small farms in general are less able to carry substantial debt burdens and are therefore much more likely to be faced with insolvency. Freshwater (1987) argues that the farms in Canada either were unable, or did not need, to reduce debt to the same extent as farms in the U.S.

The implications for competitiveness of these developments in the agricultural sectors of both the U.S and Canada seem to be well reflected in the MIC. The fact that the impacts of the financial crisis was more immediate in the U.S than in Canada is evidenced by the negative growth in the product price effect in the U.S between 1982 and 1986. Over the 1982-1986 sub-period, Canada continued to benefit from positive growth in its product price effect and managed to close the "competitiveness gap" with the U.S somewhat.

The peak in the estimated index in 1983 may be explained by the temporary decline in agricultural receipts in Canada due to successive drought periods in 1983 and 1984. Total receipts by the agricultural sector in Canada rebounded partially in 1984.[5] This caused the index to increase sharply, though it still fell short of its previous peaks in 1978 and 1979. The developments of the 1982-1986 sub-period and the attendant structural adjustments which occurred in the agricultural industries of both countries caused the "competitive gap" possessed by the U.S to diminish substantially. The upshot of these developments for U.S competitiveness is evidenced by the deterioration of the index from 1.51 in 1982 to 1.156 in 1986 (indicative of declining U.S competitiveness). By the end of the period, the U.S's "competitive gap" with Canada was the narrowest since the switch in 1972, as evidenced by the value of MIC which stood at 1.156 in 1986.

---

[5]The increase in sectoral receipts in 1983 is explained largely by the fall in aggregate agricultural output in Canada which was substantially below trend. It may be useful to reiterate that the U.S still possessed overall competitive advantage.

It is in the wake of these circumstances that the U.S Food Securities Act of 1985 was passed. One of the major impacts of this legislation was a cut in the loan rate.[6] Between 1980 and 1985 producers did not redeem stocks since the loan rate was above the market price. As a result the CCC's accumulation of stocks increased from U.S $570 million in 1979 to U.S $2,662 million in 1985. This rapid accumulation of stocks and the increased deficiency payments to producers led to a cut in the loan rate by 25-30% in 1986 (Gardner, 1990). CCC reform was only part of the general thrust in the U.S to overhaul farm programs to make them more responsive to market forces. Agricultural policy reform was also aimed at recapturing U.S market shares, which in many cases were perceived as being lost due to unfair trade practices (USDA, 1991). Though the loan rate was cut, income to producers was not affected in 1987 since the deficiency payments continued.

In Canada, the impact of the 1985 U.S. Farm Bill was felt via depressed prices for wheat in 1987. In 1987 wheat prices received by producers in Canada were 50% lower than in 1984-85. While this affected all producers equally, Oleson (1987) argues that it was particularly hard on exporters who relied heavily on export revenues. Canada exports the largest percentage of domestic production (80%) of any major exporting country.[7] Consequently, the impact of this decline in prices for the agri-producing industries in Canada was serious.

---

[6]The loan rate is the rate at which the Commodity Credit Cooperation (CCC) makes loans to producers, using the producer's stock of commodity as collateral.

[7]In comparison, only 50% of total U.S production is exported (Oleson, 1987).

Over the 1987-1989 period Canada's aggregate agricultural output also declined by 3.23% relative to the 1982-1986 period. In addition, while the adjustments to the financial crisis of the 1980s may have been delayed in Canada, they were by no means postponed. Meilke and Warley note that by 1987, 12.5% of Canadian farm borrowers were in financial difficulty. They further contend that of those farms in difficulty, 30% were insolvent and 33% more were expected to be insolvent by 1989. They further note that in 1987, an additional 5.2% of farms were classified as financially vulnerable.

Faced with rapidly declining wheat prices, Canada was forced to increase government expenditures on agriculture. A comprehensive review of the programs intended by Canada to deal with declining farm incomes is provided by Meilke and Warley (1990). Of particular relevance to the present discussion was the support given to producers through Canada's ad-hoc programs. Historically these programs were used to compensate producers for natural disasters. Meilke and Warley argue that the most important and expensive program was the institution of the Special Canada Grains Program (SCGP) in late 1986. This was in direct response to the decline in the world price for grains induced in part by the cut in the CCC's loan rate by the U.S. Payments were made under this program for the 1986 and 1987 crop years, though no payments were made for the 1988 crop.

In the early 1980s trade tension between the U.S and Canada began to resurface. Canada and the U.S also began charging the EEC with dumping heavily subsidized products in the world market, which eroded the "genuine comparative advantages" of competitors (Oleson, 1987).

In the U.S two programs were initiated to deal with these "unfair trade practices"; the Export Enhancement Program (EEP) and the Market Promotion Program (MPP). Contemporaneous with this was the depreciation of the U.S dollar against other major currencies in 1985. U.S exports did not respond to these initiatives immediately and exports declined even more in 1986, before rebounding in 1987. While the value of U.S exports in 1986 was U.S $26.0 billion, by 1989 it had increased to approximately U.S $39 billion.

The problems of the Canadian agricultural sector were exacerbated by the strengthening of the Canadian dollar against the U.S dollar from 1987. In addition, the effects of the financial crisis had begun to cause serious repercussions in Canadian agriculture.

These factors along with the attendant changes in agricultural policy between countries, coupled with the fact that the agricultural sector in Canada was in the midst of adjusting to the financial crisis of the early 1980s, helped to give the U.S a decisive competitive advantage in agriculture from 1987-1989. Between 1987 and 1989, the estimated index increased from 1.25 to 1.63, mirroring the strong recovery of U.S agriculture vis-a-vis that of its Canadian counterpart.

Comparison with Other Studies on U.S-Canadian Agricultural Competitiveness

The central focus of this study is the development of a theoretically-based index of competitiveness and its application to the measurement of competitiveness between the U.S and Canadian agri-producing industries. In this regard, comparison with other studies essentially is reduced to a comparison of the implications concerning competitiveness

obtained from the index developed in this study, with those obtained in other studies.

The only studies which assess bilateral competitiveness in agriculture between the U.S and Canada are those conducted by Vollrath and Vo (1988) and Vollrath (1991). Vollrath and Vo (1988) proposed an index of "revealed agricultural competitiveness" (RAC), which is a trade-based measure that recognizes distortions and trade imbalances occurring due to government actions that alter relative prices and distort the pattern of trade. The RAC index uses information on both relative supply and relative demand in the determination of relative competitiveness.[8] When a country has an RAC greater than zero it has a competitive advantage for the commodity. When a country has an RAC equal to zero it has neither a competitive advantage or disadvantage for the commodity. A country having an RAC less than zero has a competitive disadvantage for the commodity. The connection between the RAC index and the MIC index is that a RAC greater than zero corresponds to an MIC greater than one; where this exists the country has a competitive advantage. Conversely, a country has a competitive disadvantage if RAC is less than zero or correspondingly if MIC is less than one. When either RAC equals zero or MIC equal to one neither country possesses a competitive advantage. The RAC procedure was applied to aggregate U.S and Canadian agriculture between 1961 and 1986.

Based on RAC, with the exception of the years 1961, 1964 and 1970-71, the U.S was more competitive than Canada in agriculture. This suggests

[8]In specifying the relative export and relative import equations, Vollrath used the exchange rate, land productivity, agricultural labor-augmenting capital, land- augmenting capital and the agricultural terms of trade among other variables as independent variables in the regression. (See Vollrath and Vo (1988).)

general consistency between the MIC and RAC indices. According to RAC, from 1972 the U.S showed particularly strong competitiveness in agriculture, with the competitiveness gap being largest in 1978-79 and 1982. The RAC index exhibited a decline for the U.S in 1980-81, followed by an extremely slow rate of growth thereafter (till 1986). The RAC index for Canada was characterized by continuously declining rates of growth in the 1966-1968 period. Subsequent recovery caused the RAC index for Canada to exceed that of the U.S in 1970-71. From 1972 to 1974, however, the slower rate of growth in the RAC index for Canada conceded the competitive advantage to U.S agriculture. The competitiveness gap narrowed between 1974 and 1976 due to more rapid growth in RAC in Canada than in the U.S. According to the RAC index, from 1976 the competitive advantage of agri-producing industries in the U.S was decisive, with a tendency for the RAC index in Canada to follow the same trends as the U.S's RAC index, albeit at a considerably lower level.

The other measure proposed by Vollrath (1991) is the "relative trade advantage" index (RTA).[9] A positive RTA indicates that a country has a relative competitive advantage for the specific commodity/industry, while a negative RTA indicates a relative competitive disadvantage. Vollrath assessed the competitive advantage of the U.S and Canada in agriculture between 1961 and 1989. The RTA index indicated that Canada possessed the competitive advantage in agriculture from 1961 to 1971. From 1972 to 1989 however, the U.S is shown as possessing a decisive competitive advantage

[9]The RTA summarizes how well a country competes with other countries in a particular commodity/industry and how well a particular country's commodity/industry competes for resources with other commodities or industries domestically.

over Canada in agriculture. The U.S's RTA index began to exceed that of Canada from 1972. Vollrath argued that the U.S's competitiveness in agriculture grew slowly from the middle of the 1970s to the early 1980s. He goes on to state that with a decline in grain and oilseed exports the U.S's competitiveness declined and its RTA plummeted.

According to Vollrath, with changes in the 1985 Farm Bill the U.S began competing more aggressively for export markets and agricultural competitiveness stabilized beginning in 1986. From 1986, according to the RTA index, U.S competitiveness varied little. Canada's RTA declined steadily from 1967 to 1969-70 before rising marginally in 1971. Between 1972 to 1989, three troughs are evident in the RTA index for Canada. These occurred in the years 1977-78, 1985-86 and 1988-89. Throughout the post-1972 era, the performance of the RTA index for Canada was consistently weaker than of the RTA index in the U.S.

Prior to 1971 the RTA index is consistent with the MIC index with the exception of the year 1961, however in the post-1971 period, the performances of both the RTA and RAC indices were consistent with that of MIC. On the other hand the RAC index differed from the MIC index between 1967 and 1970. These differences between the indices are not irreconcilable, since the MIC index does suggest that from 1967 to 1971 the rate of growth in VA in the U.S was more rapid than the RGVA in Canada.[10]

In general, both the RTA and the RAC indices were found to be consistent with the MIC proposed in this study. While the MIC mirrored the

---

[10]The U.S had began to close the competitiveness gap which remained narrowly in Canada's favor.

pattern of bilateral competitiveness measured via RTA, it differs slightly with the RAC index over the 1967-1970 sub-period.

Of particular relevance to this study and the focus of the following section is the anatomy of competitiveness and in particular the identification of the factors and the extent to which these said factors contribute to its determination.

Sources of Competitiveness

The decomposition of the average annual rate of growth in value added (RGVA) into its components is presented in Table 5.3. This facilitates an examination of factors central to the determination of bilateral competitiveness along with their relative importance. According to Table 5.3 Canada possessed a competitive advantage over the 1962-1967 sub-period due primarily to the technical change gap with the U.S, in addition to a favorable restricted terms of trade effect.[11] The technical change gap (2.308%) in addition to the favorable restricted terms of trade (RTOT) gap relative to the U.S. (1.354%) accounted for approximately 96.50% of the positive trend in the differential rate of change in the competitiveness index.[12]

The factor cost gap was almost negligible due mainly to the larger increases in intermediate input and hired labor prices experienced in the

---

[11]Technical change gap is the terminology used to characterize the difference in the rate of growth of technical change in the agricultural sectors of the two countries.

[12]The term restricted terms of trade effect is used to define the relative price of aggregate output between the U.S and Canada. The restricted terms of trade gap is the net effect on restricted profits (value added) of differences in the rate of change in aggregate product prices between the U.S and Canada.

Table 5.3 Sources of Increase in Restricted Profits United States and Canada, 1962-89.

Country/ Period	Source of Increase (%)							
	Restricted Terms of Trade Effect	Inter-mediate Input Cost Effect	Energy Cost Effect	Labor Cost Effect	Quasi-Fixed Labor Effect	Quasi-Fixed Capital Effect	Technical Change Effect	Ave. Annual RGRP
				Canada:				
1962-1966	3.368	-0.336	-0.037	-0.300	-1.250	0.028	5.215	5.197
1967-1971	-0.333	0.096	-0.074	-0.286	-0.679	0.026	4.304	1.845
1972-1976	-0.873	-1.100	-0.277	-0.955	-0.612	0.143	2.348	-2.029
1977-1981	3.671	-1.055	-0.378	-1.048	-0.150	0.428	0.159	1.552
1982-1986	1.854	-0.351	-0.257	-0.906	-0.323	0.359	-1.340	0.306
1987-1989	-3.561	0.270	0.298	0.220	-0.369	-0.623	-0.021	-3.786
				United States:				
1962-1966	2.015	-0.691	-0.006	-0.472	-0.940	0.618	2.907	2.496
1967-1971	0.808	-0.408	-0.055	-0.326	-0.127	1.439	3.525	3.703
1972-1976	4.664	-2.254	-0.286	-0.432	-.675	0.884	3.750	4.396
1977-1981	3.331	-1.853	-0.602	-0.336	-.086	0.590	3.898	3.598
1982-1986	-0.792	0.147	0.161	-.017	-1.403	0.178	4.166	0.829
1987-1989	2.584	-1.246	0.019	-0.177	-0.836	0.019	4.355	3.184

U.S than in Canada but the lower energy price increases in Canada than in the U.S.[13] [14] While the rate of out-migration of labor from agriculture was similar in the two countries (-5.562% for Canada, -5.2165% for the U.S), the increased flexibility in Canada as evidenced by the higher elasticities of output and cost with respect to operator-family labor caused the negative impact on VA in Canada to be somewhat larger than in the U.S.[15] Conversely, the rate of growth of capital input in Canada was nearly three times that of capital growth rate in the U.S. However, the positive effects on VA in Canada were substantially less than in the U.S as a result of the greater flexibility exhibited by the elasticity of cost and output with respect to capital in the U.S than in Canada (Table 5.3).

In the 1967-1972 sub-period, the source of Canada's competitive advantage over the U.S changed somewhat. The RTOT began to contribute negatively to Canada's growth in VA for the first time since 1961. The negative growth in the RTOT was induced by a 0.3% decline in the aggregate output price received by the agricultural sector in Canada. Concomitant with this, was the positive growth in RTOT recorded by U.S agricultural industries, initiated by a 1.3% increase in aggregate output prices. These

---

[13]The factor cost gap is defined as the difference in the rate of change of variable costs between countries due to changes in variable input prices.

[14]Government policy in Canada allowed domestic oil prices to rise more slowly than the world price, so that domestic industries would not be subject to the full effects of the increases immediately. Over the 1972-1976 and 1977-1981 sub-periods, the price of energy in Canada increased by 7.72% and 10.0% respectively, as compared to 12.06% and 16.83% over the same sub-periods for agri-producing industries in the U.S.

[15]The term flexibility is used in relation to the ability of factors to respond quickly to price and output shocks, as evidenced by the magnitude of the various elasticity estimates.

two trends in RTOT reinforced each other leading the RTOT gap to switch in favor of the U.S. By the end of the decade of the 1960s the RTOT gap was 1.14 in favor of the U.S.[16] In Canada, as in the U.S, all other variables exerted impacts on MIC which were more or less similar to that of the 1962-1966 sub-period.

As previously indicated, in 1972, the estimated MIC became greater than 1, indicative of the U.S becoming more competitive than Canada in agriculture. Over the 1972-1976 sub-period the U.S's competitive position was reinforced by a favorable RTOT (4.66) and by an increase in the growth rate of TFP (refer to Table 5.3).

In sharp contrast the performance of the Canadian agricultural producing industries continued to be weak, both in relation to the U.S, and to its earlier performance over the 1962-1966 period. The impact of the negative growth rate in the RTOT in Canada on VA would actually have been larger were it not for the continued rapid rate of growth in technical change (3.062%). However these favorable gains in technical change were eroded by the sharp increases in the prices of all inputs, in addition to continued deterioration of the RTOT which averaged -.87% over the 1972-1976 period. The implications of this for MIC were that over the 1972-1976 period, the U.S's RTOT gap with Canada widened by 5.537%. In addition a technical change gap favoring the U.S had emerged, over the 1972-1976 period the gap was 1.402%. The differential rate of growth in these two factors accounted for approximately 98% of the positive trend in the change in the bilateral competitiveness index.

---

[16]The interpretation of the RTOT gap is that 58% of the positive growth in the average annual RGVA (1.969), is composed of differences in the rate of growth of VA between the U.S and Canada.

While the U.S retained its competitive advantage in the 1977-1981 sub-period, Canadian agriculture regained some of the lost competitiveness to the U.S for the first time since 1972. This is evidenced by the decline in RGVA to 2.046. Renewed growth in Canada's RTOT over the 1977-1981 sub-period was spurred by a 5.236% increase in aggregate product price, this caused a switch in the RTOT gap in Canada's favor. However the technical change gap which previously had favored Canada prior to 1971, moved strongly in favor of the U.S in the 1977-1981 sub-period. This was initiated by the slow rate of growth in technical change, which occurred simultaneously with an increase in the rate of technical progress in the U.S. The relative effect of the other factors on bilateral competitiveness continued to be negligible, since they exhibited impacts which were quite similar between countries. Over the 1977-1981 period the technical change and RTOT gaps accounted for nearly 97% of the positive variation in the index.

The Canadian agricultural sector continued to record slower growth in VA than their counterpart in the U.S, over the 1982-1986 period, with the average annual rate of change in VA declining to 0.829%. The difference in the rate of change of VA between the two countries (0.523%) reflects a closure of the competitiveness gap by Canada over the 1982-1986 period. Nonetheless, the agricultural sector in the U.S still retained its competitive advantage throughout the period. The down-turn in the U.S was fueled by a decline in aggregate product prices and the level of quasi-fixed labor which had declined by 4.7% relative to the previous period. The continued positive contribution of technical change in the U.S cushioned the negative impacts of the changes in the RTOT and quasi-fixed

labor on VA and on U.S competitiveness. In comparison, the growth in VA experienced by the agricultural sector in Canada was generated more by positive growth in aggregate product prices, than by growth in technical change, which stagnated over the 1982-1986 period.[17]

The 1987-1989 period was marked by the continued competitive advantage of U.S agricultural producing industries and the reversal of the positive trends in VA displayed by Canadian agriculture in the preceding sub-period. Due largely to the absence of technological progress in Canada, the technical change gap continued to favor the U.S. Over the 1987-1989 period the U.S's technical change gap with Canada was 4.376%. The U.S also reversed the RTOT gap which favored Canada in the preceding period. The impetus for the reversal of the RTOT gap with Canada was provided by a 4.16% increase in aggregate product price by the agricultural sector in the U.S concomitant with a 4.84% decline in aggregate agricultural product prices in Canada. Over the 1987-1989 period the differential rate of growth in VA between the agricultural sectors of the two countries reached its highest level for the entire coverage period of just under 7.0%.

In general between 1962-1989, the factor cost gap was not found to be a major determining factor in regard to changes in VA and hence on competitiveness between U.S and Canadian agriculture. Similarly the levels of family labor and capital did not significantly affect VA or by

---

[17]The magnitude of year to year estimates of technical change over the 1982-1986 and 1986-1989 periods were extremely small. The estimates were also statistically insignificant. As such even though the absolute values are entered in Table 5.3 along with the associated negative signs, the effect of the rate of technical change on cost and competitiveness is taken to be negligible.

extension competitiveness between the U.S and Canadian agricultural sector. Accounting for quasi-fixity through the short-run framework specified in this study can be potentially important in explaining differential responses to exogenous shocks. However, the short-run response of these factors on VA were so similar between countries that it minimized the importance of factors as crucial determining sources of changes in VA and hence competitiveness between U.S and Canadian agriculture.

The technical change gap accounts for a significant amount of the positive variation in the bilateral competitiveness index (MIC), 71% in the 1977-1981 period. In Canada, VA appeared to be particularly sensitive to changes in the rate of technical change. In periods such as 1967-1971 and 1972-1976, the rapid rate of technological progress acted to offset the full impact of deteriorations in the RTOT. In Canada reductions in the rate of technical change were also offset by improvements in the RTOT. Technical change has been important in a more subtle though non-quantifiable sense. This again is more reflective of the Canadian situation, where in the post 1976 period technical change has acted as a signal of impending deterioration in overall agricultural competitiveness.

Given the obvious importance of the rate of technical change in the determination of the bilateral competitiveness index, further examination of the pattern of technical change and its role in inducing growth in aggregate agricultural output is warranted.

Role of Technical Change

Tables 4.11 and 4.12 provide estimates of technical change for Canadian and U.S agriculture respectively, from 1962-1989. The rate of

technical change was higher in Canada than in the U.S over the 1962-1971 period. Between 1962 and 1971 the rate of growth of technical change in Canada averaged 6.1% per annum in comparison to a rate of growth in the U.S of 3.2% over the same period. The following period, 1972-1976, witnessed a slowdown in the annual growth rate of technical change in Canada, and a slight increase in the annual rate of growth of technical change in the U.S.

Over the decade of the 1960s, the growth rates of technical change differed substantially between the two countries. The per annum rate of growth in technical change in Canadian agricultural exceeded that of the U.S by 2.9%. From 1977 however, the rates of technical change in the two countries began to diverge even more than in previous period. Technical change slumped drastically in Canada from an annual rate of approximately 3.1% over the 1972-1976 period to just approximately 0.2% per annum between 1977-1981. Over the same period the U.S's per annum growth rate of technical change remained roughly constant, averaging 3.90%. By the end of the 1980's sharp differences were apparent in the annual rates of technical change between the U.S and Canada. While technical change in Canada had stagnated, technical change in the U.S had accelerated to an average of 4.34%, due largely to strong performances in 1986 and 1987.

The trends in the rate of technical change and the observed trends in MIC have followed each other quite closely. In the pre-1972 era when the technical change gap favored Canada the competitiveness gap also favored Canada, and the agricultural sector in that country outperformed the sector in the U.S. In the post-1972 era however, the agricultural sector in Canada experienced large reductions in technical change and

aggregate output, this caused both the technical change and competitiveness gap to favor U.S agriculture.[18]

Table 5.4 indicates that the contribution of technical change to the growth in TFP was fairly similar in the U.S and Canada. While 98.0% of the positive variation in TFP growth in the U.S is accounted for by technical progress, in Canada 96.30% of the positive variation in the rate of TFP growth is attributable to the growth rate of technical change.[19] [20] The role of nonconstant returns to scale and the aggregate price effect accounted for the remaining variation in TFP growth between countries. The contribution of the aggregate price effect to the growth rate of TFP varied substantially between sub-periods and countries, though the effect was quite similar between countries viewed over the entire 1962-1989 period.

Technical change has also been an instrumental factor in the rate of growth of aggregate agricultural output between countries. Table 5.5 indicates that the U.S. agricultural sector experienced slower growth in aggregate output (2.27%) than Canada over the 1962-1976 period. The growth

---

[18]This finding is consistent with that of other authors (Ostry and Rao (1980) and Rao and Preston (1984)). Both studies found that there was a general slowdown for all industries, including agriculture in the post-1973 period. The technical change estimate for the 1974-1979 period in the study by Rao and Preston (1984) of 0.74% is even smaller than the estimate in this study which was 1.26% over the same period.

[19]The aggregate price effect is the sum of the difference in actual and predicted shares of all variable and quasi-fixed factors.

[20]The presence of both positive and negative values made application of percentages awkward. To minimize confusion all negative values were considered as contributing to the negative variation in the choice variable, these influences sum to 100%. Conversely variables with positive values were considered as contributing to the positive variation in the choice variable, these also sum to 100%.

in output was partially accounted for by increases in the level of intermediate inputs and energy. The contribution of intermediate inputs and energy to the positive variation in the rate of growth in aggregate output was 25% and 4.60%, respectively. The contribution of capital to the positive variation in output growth in the U.S was 3.4%.

Table 5.4 Decomposition of TFP Growth, United States and Canada, 1962-1989.

		Percentage Contribution to TFP Growth.		
Period	Average Annual TFP Growth (%)	Nonconstant Returns to Scale	Technical Change	Aggregate Price Effect
		United States		
Period:				
1962-1989	1.58	-100.00	98.00	2.00
		Canada		
Period:				
1962-1989	1.12	-100.00	96.30	3.60

A substantial portion of the positive variation in the growth in output, 67%, was attributable to the rate of technical change which grew by 3.44% per annum over the 1962-1976 period. Relative to Canadian agriculture, over the pre-1976 era the rate of capital accumulation was slower and the rate of growth of intermediate inputs and energy utilization more rapid in the U.S.

In Canada the higher rate of technical change experienced (6.109% in the pre-1976 period) relative to the U.S over this period, reinforced the

Table 5.5 Accounting for Growth in Aggregate Output, United States and Canada, 1962-1989.

	Relative Importance of Various Facors to Growth in Output (%)						
	Rate of Growth of Aggregate Output	Technical Change	Inter-mediate Inputs	Energy	Hired Labor	Quasi-Fixed Capital	Quasi- Fixed Labor
				Canada			
Period:							
1962-1976	3.16	67.00	-12.27	-3.00	-3.20	33.00	-81.53
1977-1989	1.49	1.00	14.80	1.90	5.20	77.00	-100.00
				United States			
Period:							
1962-1976	2.27	67.00	25.00	4.60	-12.00	3.40	-88.00
1977-1989	2.17	83.00	17.00	-7.40	-10.20	-14.70	-67.70

downward trend in input usage and contributed to a higher rate of aggregate agricultural output. Technical change accounted for 67% of the positive variation in aggregate output growth, the remaining 33% was attributable to the rate of capital accumulation.

In the post-1976 era, led by continued growth in the rate of technical change, (which grew to 4.102% over the 1977-1989 sub-period) the agricultural sector in the U.S outperformed its counterpart in Canada. Between 1977 and 1989 technical change accounted for 83% of the positive variation in aggregate agricultural output in the U.S. In contrast, the contribution of the rate of technical change to the growth in aggregate agricultural output in Canada was insignificant. Over the 1977-1989 period, stagnation in the rate of technical change appears to have retarded the growth rate of aggregate agricultural output which had slowed to an annual rate of just under 1.5%. In the post-1976 period the majority of the growth in aggregate output in Canada , was explained by growth in quasi-fixed and variable factors.

In terms of variable inputs, over the 1977-1989 period, the increased utilization of intermediate inputs and hired labor helped to cushion the impact of the slow-down in the rate of technical change. In addition, there was an increase in the rate of capital accumulation, which also assisted in offsetting the negative impacts of the technical change slow-down.

While the rate of growth of aggregate output had slowed in both countries, the slow-down was more severe for Canadian agriculture than for the U.S, where aggregate output had declined moderately. Over the 1962-1976 period, the contribution of technical change to the growth of

aggregate agricultural output was 67% for both the U.S and Canadian agricultural sectors. In Canada in the post-1976 era, growth in aggregate inputs and the positive rate of capital accumulation were responsible for the majority of the growth in aggregate agricultural output. The slowdown in the aggregate rate of output growth was due primarily to the stagnation of technical change and to out-migration of quasi-fixed labor from agriculture.

As a percentage of all factors which tended to retard growth in aggregate agricultural output, reductions in the number of hours worked by operator and family labor constituted 80% of the negative variation in Canadian agricultural output in the post-1976 period (Table 5.5). The negative influences on aggregate agricultural output were however outweighed by the positive influences, resulting in a net positive growth rate of aggregate agricultural output of 1.5%. The difference between the growth rate of aggregate agricultural output between the pre-1976 and post-1976 era is attributable to the stagnation in the rate of technical change and to the slower rate of capital accumulation in the post-1976 period.

The rate of technical change accounted for approximately 72.6% of the slowdown in aggregate agricultural output, while the slower rate of capital accumulation accounted for the bulk of the remaining 27.4%.[21] In the U.S during the post-1976 era the contribution of technical change to

[21]The only two variables to exhibit declining rates of growth in the post-1976 period relative to the preceding period in Canada were technical change and the rate of capital accumulation. All other variables reflected positive growth relative to the pre-1976 period. The importance of the rate of technical change and the rate of capital accumulation was therefore calculated by apportioning the decline in aggregate agricultural output between the two periods to these two variables.

growth in aggregate agricultural output was 61.6%, the remaining 37.9% was attributable to growth in aggregate inputs.

Economic theory identifies two major sources of gains from trade. Increased efficiency from resource reallocation and productivity gains acting through scale economies and rationalization. Trade in this framework has an effect similar to an overall improvement in technical progress and enhances the productivity of all factors. Helpman and Krugman (1985) suggest that rationalization and scale economies play a far more important role in improving productivity growth among countries (particularly in a free trade setting) than resource reallocation between industries.[22] This suggests that one likely impact of freer trade between the agricultural sectors of the U.S. and Canada is a reduction in the size (scale) of operations. This might arise from firms being forced to produce at or closer to the minimum point on their average cost curve. TFP growth might also be increased from the reallocation of resources from declining to growing industries.

The arguments of Helpman and Krugman are predicated on the assumption that the industry is characterized by increasing returns to scale. With decreasing returns to scale, rapidly rising marginal cost will rapidly eliminate any gains created by an increased market. Thus, the opportunities which freer trade creates will be realized primarily through

---

[22]Rationalization in the context of this study refers to a reduction in the number of sub-optimal firms in total agricultural production. In contrast to the reductions in diseconomies of scale (which depends on a movement along the average cost curve, such that a reduction in average costs is derived from decreases in the output of the industry), rationalization speaks to the benefits which accrue from restructuring of the industry (from a downward movement in the industry's average costs). Rationalization is therefore independent of changes in the size (output) of the industry.

a reduction in the scale of production. In the absence of rationalization, the study's finding of large diseconomies of scale in the U.S. and Canadian agricultural sectors will mitigate against freer trade leading to favorable effects on competitiveness.

There have been relatively few econometric studies that have examined the sources of growth within the agricultural sectors of the U.S and Canada.[23] The Economic Council of Canada has recently completed a study on "Comparisons of the Production and Cost Performance of Canadian and U.S Industries." by P. Rao. The results of this study indicate that for Canadian agriculture the rate of TFP growth between 1962 and 1988 was 1.3%. Table 4.11 indicates that this result is in the range of the estimated growth rate in TFP (1.118%) found by this study. In addition Rao and Preston (1984) found that the growth of TFP in Canadian agriculture was -0.78% and -1.96% over the 1963-1973 and 1974-1980 sub-period respectively.[24] In this study they suggested that in computing aggregate TFP, the terms of trade effect should be incorporated. Rao and Preston also concluded that since the terms of trade effect "disappeared" in the post-1973 period, part of the productivity slowdown attributable to inter-industry shifts might have been accounted for by a deterioration in the terms of trade.

This conclusion by Rao and Preston is important to this study in two respects. First, it lends support to the specification of the theoretical model and its subsequent decomposition. More importantly, however, is

---

[23]See Capalbo and Antle (1988).

[24]Rao and Preston also argue that reductions in productivity growth could be caused by declining output growth, especially if fixed or quasi-fixed inputs were installed in expectation of rises in output.

their finding that the terms of trade effect disappeared in the post 1973 period, a conclusion which is supported by this study's findings. Rao and Preston also found that a substantial amount of the slowdown in aggregate output was explained by a slowdown in the rate of TFP growth (85%). In the present study, 72.6% of the rate of growth in aggregate output was explained by the deterioration in the rate of technical change. In addition the RTOT for Canada was negative over the 1967-1971 sub-period with subsequent recovery occurring from 1978. Our estimate of the contribution of technical change to output growth is therefore somewhat lower than that of the Rao and Preston study.

Capalbo (1988) found the annual growth rate of TFP for U.S agriculture between 1950 and 1982 to be 1.56% per annum. This is virtually the same as the estimate of 1.584% found in this study. Capalbo also found that the rate of technical change accounted for approximately 89% of the rate of growth in aggregate output. Capalbo's estimate of the contribution of technical change to aggregate output growth exceeds the 67% estimate found in this study for the corresponding period. While the decomposition of TFP growth is similar in both the study by Capalbo and by Rao and Preston, it differs somewhat from the one pursued here. The decomposition pursued here includes an aggregate price effect, which allows variations in both the observed and shadow shares of quasi-fixed and variable factors to contribute to variations in TFP growth (see equation (3.21)). It appears that by virtue of this, the present study assigns more importance to inputs and less to technical change than the studies of Rao and Preston, and Capalbo. In general the results of this study are consistent with the results of the studies by Rao, Rao and Preston and Capalbo.

CHAPTER VI
SUMMARY AND CONCLUSIONS

Summary

Considerable effort has been devoted in the past to the measurement of competitiveness. Most of these studies, however, have emphasized cost competitiveness, with little regard for product price interactions. In addition, most of the efforts in evaluating competitiveness to date have assumed long-run equilibrium for all factors of production.

Since overall country competitiveness depends, on both cost and revenue factors, among other determinants, in addition to productivity and exchange rate changes, focusing only on cost factors can lead to misleading insights. The impacts of relative product price changes and quasi-fixity should be included in any framework which aims at explaining changes in international competitiveness, as they are likely to be significant determinants. Accounting for these determinants can provide useful information to both policy makers and industries.

This study attempted to address some of these shortcomings by the specification of an econometric model of U.S. and Canadian agriculture, which incorporated behavior and revenue effects in a partial equilibrium framework. These specifications provided the basis for measuring the influence of various economic factors on agricultural competitiveness and facilitated the measurement of the impacts of technical change in both countries, as well as input demand and supply elasticities.

The parametric estimates were used in the construction of a bilateral competitiveness index. The technical change variable entered the estimated model as a time trend. The supply price was a combination of market sales revenue and government payments. As such it was implicitly assumed that the effective average revenue was equal to the marginal cost at the observed level of output. Both the U.S. and Canadian models were estimated using time series data from 1961-1989 and estimated via non-linear three stage least squares (NL3SLS) with instruments.

Results

The analysis suggests that most of the difference in competitiveness between the U.S. and Canadian agriculture is attributable to two factors: the restricted terms of trade (RTOT) gap and the technical change gap. The contribution of these two factors to the variation in the estimated index ranged from 71% over the 1977-1981 period to 98% in the 1972-1976 period. The empirical results also suggests that from 1962-1971, technical change strengthened the competitive advantage of Canadian agriculture.

The role of technical change in accounting for total factor productivity (TFP) growth was also significant. Over the 1962-1989 period, technical change accounted for 62.45% of the annual rate of growth in TFP for Canadian agriculture. In the U.S. 63.53% of the annual rate of growth in TFP was explained by technical change. The favorable rate of technical change which had previously existed in the Canadian agricultural sector was undermined by the negative rates of change exhibited by both the RTOT and factor cost effects.

Technical change was an instrumental factor in the post-1976 slow-down in Canadian agriculture. The results suggest that approximately 77%

of the post-1976 slow-down in aggregate agricultural output in Canadian agriculture was accounted for by the stagnation in technical change.

Decreasing returns to scale impacted the rate of TFP negatively in both the U.S. and Canada. In addition, scale diseconomies also played a significant role in the post-1976 slow-down in Canadian agriculture. The results of the study suggest that diseconomies of scale accounted for approximately 75.0% and 36.0% of the slowdown in TFP growth over the 1977-1981 and 1982-1986 sub-periods, respectively.

The empirical results also indicate that the aggregate price effect was equally important to the agricultural sector in both the U.S. and Canada. Over the 1962-1971 period the aggregate price effect reinforced the rapid rate of growth of technical change and contributed to Canada's competitive advantage.

The two oil shocks in 1973 and 1977 impacted TFP growth in both countries in a negative manner. The impact was more pronounced in Canada than in the U.S. The principal reason for this was the greater responsiveness of cost and output to energy price increases in Canada as opposed to the U.S. While the impact of the factor cost gap in the determination of competitiveness was negligible, the rate of growth of aggregate inputs constituted an important source of growth for aggregate agricultural output. It is primarily through this medium that the rate of growth of factors (weighted by their individual cost shares) exerts influence on the bilateral competitiveness measure.

Differential rates of growth in capital (capital accumulation) were an important distinguishing factor on the rate of TFP growth between the agricultural sectors in the U.S. and Canada. Prior to 1982 the rate of

capital accumulation in Canada was approximately three times that of its U.S. counterpart. Over the 1987-1989 period, however, the rate of growth of capital accumulation fell in both the U.S. and Canadian agricultural sectors, causing the contribution of this factor to the rate of growth of aggregate agricultural output to decline in both countries. The slower rate of capital accumulation in both countries impacted the general decline witnessed in both the rate of growth of aggregate agricultural output and bilateral competitiveness positively in the post-1976 period.

While the rate of capital accumulation in Canada continued to be positive in absolute terms before and after 1976, it declined by approximately 60% between the 1962-1976 and 1977-1989 periods. In the U.S. while the rate of capital accumulation was positive over the 1962-1976 period averaging 1.09% per annum, after 1976 the rate of capital accumulation became negative, (-.535%).

The depreciation of the Canadian dollar against the U.S. dollar in the early 1980s contributed positively to the narrowing of Canada's competitiveness gap with the U.S. between 1982 and 1986. From 1986 to the end of 1989 the weakening of the U.S. dollar against other major currencies also contributed to the resurgence of its previous dominant competitive edge.

The volatility of exchange rate changes coupled with the sharp decline in the competitiveness index upon currency realignment suggests that the impact of this factor on competitiveness was positive in the short-run. This suggests that the impact of a weak Canadian dollar on competitiveness in the 1982-1986 period was short-lived. In addition, though not tested directly in the present study, there remains the

possibility that the depreciation of the Canadian dollar may have retarded productivity and competitiveness in subsequent time periods.

Due to data limitations the study was unable to measure "true" competitiveness, which is closest to, but not coincident with comparative advantage. Instead the study has focused on "market" competitiveness which includes the influence of government induced agricultural and trade distortions. In addition to data limitations, uncertainty has been raised as to whether true competitiveness can be measured in the present framework. This uncertainty arises because even if the contribution of government payments to average receipts was known, the impact on both input demands and the aggregate supply functions in the absence of policy remains unknown, and given historical data, unmeasurable. This difficulty is further compounded by the fact that not all government contributions are necessarily distortionary, (e.g. expenditures for research and development). While conceptually a measure of true competitiveness is attainable, practical considerations preclude its construction.

The results of this study suggest that the agricultural sector in Canada is declining in competitiveness relative to the U.S. This has been primarily due to the stagnation in the rate of technical change and a deterioration in its restricted terms of trade. While movements in the restricted terms of trade are somewhat volatile, the influences of technical change are stable and somewhat more persistent. Therefore, policies aimed at increasing the pace of technological advance in Canadian agriculture appear to be the primary facility for increased competitiveness. Indeed, increasing the rate of technical change is particularly important in the Canadian context, since the country does not

possess the fiscal base on which to compete with the U.S. or other competitors on the basis of direct government support to agriculture.

Conclusions

The results of this study suggest that possibly the only manner in which freer trade can contribute to increased competitiveness is by inducing industries, through more aggressive competition with each other, to adopt new technology more rapidly, so as to retain or improve their competitive position (increased rate of technical change). However, while reductions in diseconomies of scale can potentially enhance competitiveness, the realization of these potential gains rests critically on the ability of both the U.S. and Canada to satisfy a number of necessary preconditions.[1] In this regard Erickson et al. (1986), commenting on barriers to U.S.-Canadian trade in agricultural commodities argues that non-tariff measures are the most difficult to deal with, since issues like phyto-sanitary requirements, and grades and standards lack a quantifiable basis on which agreement can be sought or negotiations made. Without the elimination of these measures, as well as the other border measures which restrict trade between the two countries, it is doubtful that the expected benefits from freer trade will be realized.

The foregoing analysis also suggests that the larger the diseconomies of scale, the smaller the likelihood that the sector will benefit from freer trade. However, with increased import competition, industry rationalization may offset some of the negative impacts induced by rapidly rising marginal costs. Import competition will force domestic

[1]This appears to be explained by policy-induced distortions which cause the agricultural sectors to respond to "incorrect" price signals, leading to overproduction.

firms to adopt new technology more rapidly, in a bid to retain or improve their competitive position. If the major impact of freer trade is, however, a larger export market, then in the absence of any other countervailing factors, its ability to enhance competitiveness will not be significant, due to the rapidly rising marginal cost.

The larger diseconomies of scale in Canada between 1961 and 1989 suggest that the potential gains to Canada from freer trade may be relatively larger than the benefits to the U.S. if rationalization gains outweigh the negative impacts of the diseconomies of scale effect. If this is not the case, however, then the agricultural sector in Canada will gain less than the sector in the U.S. due to faster rising marginal costs.

This outcome is also likely to be affected by the extent to which domestic programs presently in place in both countries are reduced. Without the elimination of government sponsored support for agriculture in both the U.S. and Canada, the actual extent of benefits resulting from freer trade remains an open question. An evaluation of the potential benefits of alternative scenarios for competitiveness was not part of the present study.

This does not however imply that initiatives aimed at achieving freer trade should not be pursued. On the contrary, moves to reduce both trade and domestic barriers to trade between the U.S. and Canada should continue to be an integral part of on-going initiatives in both countries to enhance the competitiveness of their respective agricultural sectors.

The results of this study suggest that several factors have contributed to the determination of competitiveness. The model of bilateral competitiveness has provided a framework, within which these

factors can be integrated and discussed. Based on the framework developed, changes in the restricted terms of trade and the rate of technical change are the two most important determinants of competitiveness for both U.S. and Canadian agriculture. Of these two factors, technical change has been most pervasive.

The conclusions of the study must, however, be tempered by the fact that the present discussion ensues at the level of the sector. Though numerous studies have looked at competitiveness at the sector level, competitiveness is most meaningful when it relates to individual firms or industries. This is because every sector has competitive and non-competitive firms.

In the foregoing analysis, the rationalization arguments presented assume that although the sector is the unit of observation, sectoral competitiveness could be enhanced under various product prices if there were changes in the number of firms and the volume of production. Analysis at the firm level was, however, not possible due to data limitations. Application of the framework at the industry level will facilitate more insightful conclusions for policy purposes.

Notwithstanding this, certain conclusions may be drawn from the analysis. For both the U.S. and Canada, the rationalization of the role of domestic agricultural policies, such that they become more market driven, will result in increased competitiveness. While it appears unrealistic to expect a total elimination of government support, the targeting of such support programs, to assist producers in adjusting to more competitive production conditions or to facilitate an exit of noncompetitive producers

from agriculture, appears to be a more appropriate objective for government assistance programs in both countries.

The discussions in the previous chapter have highlighted the importance of changes in macro-economic variables such as the exchange rate and interest rates for competitiveness. The agricultural sector in both countries can maintain their competitiveness by paying closer attention to these macro-economic variables, such that overall government policy considers the possible impacts of adverse changes in these variables on agricultural competitiveness.

Suggestions for Future Research

Notwithstanding the findings of this study which suggest the relative importance of technical change in the determination of the competitiveness index and its consistency with apriori expectations. These findings must be tempered somewhat since the study included technical change as a time trend (disembodied technical change), the occurrence of which is observed, though, largely unexplained. Technical change may also be classified as being embodied. The embodied classification is predicated on the grounds that capital cannot be instantly acquired and that technical change enters the production process through the acquisition of new inputs (usually capital).

While the embodied classification of technical change is the more realistic of the two, it is considerably more difficult to implement in empirical applications. Recent developments in the endogenous growth literature based on Schumpeterian theory, is still in its infancy. Consequently, while acknowledging the associated difficulties with the disembodied notion of technical change (particularly when time trends are

used), most empirical applications continue to be based on this definition. Since agricultural competitiveness can be enhanced by increases in the factors which contribute to accelerations in the rate of technical change; factors which impact technical change positively, such as education, extension, research and development, are likely to be particularly important. Extension of the present study to include these factors can contribute further to an understanding of the sources of competitiveness.

The analysis of the factors and the role of these factors in accounting for changes in competitiveness has also been limited by the lack of a theoretically based framework within which cross-country competitiveness could be measured when short-run equilibrium exists. This study developed a model which accounts for both cost and revenue factors within the framework of short-run adjustment and temporary equilibrium. While the bilateral competitiveness framework is most meaningful in the context of a commodity or industry, data limitations precluded analysis at such a disaggregated level.

Therefore, future research can benefit from the development of a comparable data set at the commodity or industry level, which will allow such comparisons at the industry level to be undertaken. In addition, the inclusion of differences in educational levels and research and development expenditures can go a long way in accounting for changes in the rate of technological progress between countries. Data limitations also precluded the inclusion of these aspects in the present analysis.

Useful policy insights can also be gained from the study of agricultural competitiveness between the U.S. and the EEC. This also

requires the development of a comparable set of data for both the EEC and the U.S. Such a data set is presently being constructed under the auspices of USDA. Its application to the present framework holds promise of being beneficial to future research.

Future research can also be directed to a generalization of the present framework to account for dynamic optimization and adjustments, such as through dynamic duality. Such a model may also be developed, so that it facilitates the measurement and decomposition of the sources of competitiveness into "true" and "market" determinants.

APPENDIX

DATA USED FOR THE ESTIMATION
OF U.S. AND CANADIAN MODELS

This appendix describes the data used in the estimation of the U.S. and Canadian models. The data requirements included stock levels and net investments for real estate and capital, prices and quantities of intermediate inputs, labor, energy and aggregate agricultural output. The adjustments made to maintain consistency between the U.S. and Canadian database is also discussed.

Canadian Database

The Canadian data span the period 1961-1989 and were provided by Dr. S. Narayanan, of the Farm Economic Analysis Division of Agriculture Canada. To maintain consistency with the United States data several changes were required.

Output Price and Quantity

The output data for Canada reflect total production and were obtained from Agriculture Canada. An implicit price for output was constructed using Fisher's weak factor reversal test (FWFR) (Diewert, 1976). The implicit price index is calculated by the expression:

$$P_{it} = (E_{it}/E_{ib})/Q_{it}, \qquad (A.1)$$

where P_{it} and Q_{it} represents the price and quantity indices corresponding to the i^{th} output in period t, and where E_{it} and E_{ib} represent expenditures in the expenditures in the same time period t and expenditures in the base

period b, respectively. In the context of the present model since there is only one output equation (A.3), reduces to:

$P_t=(E_t/E_b)/Q_t$, since i=1. (A.2)

FWFR test for price and quantity indices is satisfied if the ratio of expenditures in the current time period to the base period is equal is to the product of the price and quantity indices in the current time period.

The output quantity and total receipts data are based in 1981, the resulting implicit indices output price index is therefore also based in 1981.

To maintain consistency with the United States data, and in keeping with the methodology of Capalbo et al. (1986), a "flow" definition was adopted in measuring input usage.

Energy

The price of energy inputs was constructed from data on the price of fuel (gasoline, diesel, oil and lubricants), and electricity. Data on expenditures and prices for energy inputs were obtained from Agriculture Canada. By forming a Tornqvist price index the implicit quantity index was derived by dividing aggregate expenditures by the respective price index i.e., by invoking FWFR. Tornqvist price and quantity indices were then used to aggregate into a single energy price and energy quantity index respectively.

Intermediate Inputs

Intermediate inputs are an aggregate of seed, feed, fertilizer, lime, pesticide,livestock expense, custom work, wire twine and container and miscellaneous material inputs. Data on expenditures and prices of these input categories were obtained from the Agriculture Canada. FWFR was used to derive an implicit quantity index. The Tornqvist approximation to the Divisia price and quantity index was then used in the construction of an aggregate intermediate input quantity and price index.

Hired Labor

Labor input was based on annual hours worked by farm operators, family help and hired workers. Agriculture Canada uses base year average hourly wages in 1961, 1971, and 1981 respectively in its valuation of labor. While hired labor is valued at the actual hourly wage rates for farm labor, operator labor is approximated by the average non-farm manufacturing hourly wage rate. Unpaid family labor is valued at 90 percent of the wage rate for hired labor.

Because the base year weights holds wages constant for periods of ten years it proved inappropriate for the purposes of this study. These base period wage rates were replaced by annual wage rates also reported by Agriculture Canada. Wage rates for hired farm labor are published in Statistics Canada, Farm Wages in Canada.[1] Numerous authors including Capalbo et al. (1986) and Islam (1982) in confronting the same problems exploited the relationship which exists between the wage rate for farm

[1]This was suggested by personnel at the Agricultural Policy Branch of Agriculture Canada. In addition, without exception all the studies of Canadian Agriculture utilizing the Agriculture Canada Database have made this amendment.

operators and the industrial production wage rate for production workers, which are roughly equivalent. Wage rates for industrial production workers were obtained from Leisner (1989). The imputed wage rate for family labor was maintained at 90 percent of the hired farm wage rate. Annual labor hours worked were not modified and were taken directly from the Agriculture Canada database. Hired labor was aggregated into a price and implicit quantity index using Tornqvist indices.

Operator and Family Labor

Operator and family labor were similarly aggregated into a composite Tornqvist price and quantity index of quasi-fixed labor input. Both labor input indices are non-quality adjusted.

Capital

Capital input is composed of annual service flows of real estate and machinery. The annual service cost of farm use real estate was calculated by applying a real rate of interest to the constant dollar farm use portion of real estate in each year. FWFR was used to calculate implicit quantity indices by dividing current dollar expenditures by the corresponding price index. The other sub-components of real estate input are constant dollar expenses for building depreciation, building repairs and fencing expense. Current dollar expenditures of each of these sub-components were converted to a quantity index by division by the corresponding farm input price index. The real estate price index is constructed using the average value of farm land and building, the farm use real estate quantity index is calculated by dividing current dollar farm use real estate by the constructed farm use real estate price index. The building replacement price index is constructed using the cost of farm

building replacement. The building depreciation quantity index is estimated by dividing the current dollar building depreciation by the building replacement price index. Current dollar building repair estimates used to construct the building repair quantity index via division by the corresponding building replacement price index. Annual nominal dollar estimates of fencing expenses are converted to the fencing quantity index by dividing by the fencing price index.

Similar procedures were used to aggregate farm machinery. Total farm machinery inputs are the sum of the service flows from the constant dollar value of farm machinery and the annualized constant dollar value costs of machinery depreciation and repairs. The service costs of machinery inventory capital investment are measured by applying a representative nominal interest rate to the annual machinery inventory value. Since a representative rate was unavailable, a mean interest rate representative of the mix of long- and short-run borrowing was used. Annual nominal dollar estimates of machinery depreciation charges are converted to the machinery depreciation quantity index by dividing by the appropriate price index of machinery depreciation. Annual depreciation rates for farm machinery depreciation used in the Agriculture Canada database are consistent with figures from the Database for OECD Countries Keese (1991), and were used without modification in the study. Nominal dollar estimates of machinery repairs expenses are converted to the machinery repairs quantity index by dividing by the machinery maintenance price index. Real estate and farm machinery inputs weighted by the appropriate shares were aggregated into an aggregate price and quantity index of capital by the Tornqvist approximation to the Divisia index.

Consumer Price Index and Per Capita Gross National Product

Gross Domestic Product and Consumer Price Index figures used in the estimation of the demand system for Canada were obtained from the International Monetary Fund, International Financial Statistics (1980,1990). The population figures were taken from the United Nations Department of International Economic and Social Affairs, Monthly Bulletin of Statistics (1965-1990).

This data was also used to construct estimates of Real Per Capita Gross Domestic Product and aggregate consumer expenditures which constituted part of the instruments variable set used in the estimation process.

United States Database

The United States data covered the period 1948-1989. The data are unpublished and were provided by Dr. Eldon Ball of the Resources and Technology Division, Economic Research Service, United States Department of Agriculture. Variable definitions are consistent with those given in Ball (1985), but the series have been revised and extended to 1989.

Output Price and Quantity

The output indices measure quantities marketed including unredeemed, Commodity Credit Corporation loans plus changes in producer inventory and consumption by farm households. The data reflect total receipts by producers and includes direct payments to producers under government programs. The eleven categories of agricultural output covered by the database include: livestock products, dairy, poultry and eggs, food grain, feed grain, oilseeds,cotton, tobacco, vegetable, fruit and nuts, and other field crops. These outputs have been aggregated into an aggregate price

and quantity index of aggregate farm output using Tornqvist price and implicit quantity indices.

Energy

Data on energy inputs includes expenditures on petroleum, fuel and electricity. These were used to construct Tornqvist price and implicit quantities indices of energy.

Intermediate Inputs

Intermediate inputs were classified so as to maintain consistency with the Canadian data. This category included expenditures on lime, pesticides, fertilizer, agricultural services, livestock expense and miscellaneous expenses. The miscellaneous subcategory is composed of custom work and veterinary service charges, and machine hire. The Tornqvist approximation to the Divisia index was used to aggregate intermediate inputs into price and implicit quantity indices.

Labor

The database decomposes labor into two sub-categories: the first category being hired labor and the second self-employed labor. As with the Canadian data labor was not quality adjusted. The quantity of labor was measured by hours worked annually, and was aggregated by the Tornqvist approximation to the Divisia index into price and implicit quantity indices of hired and self-employed (owner operator and family labor) labor respectively.

Capital

The capital input data was calculated from information on investment and outlay on capital services (see Ball (1985). The perpetual inventory method proposed by Christensen and Jorgenson (1969) is used to estimate

the capital stock for machinery and real estate inputs. The capital stock formula, which relates net investment and the capital stock is given as:

$$A_{it} = (1 - \delta) A_{t-1} + I_t \tag{A.3}$$

where I is gross investment, K is the capital stock and δ is the rate of depreciation. Jorgenson (1974) established that the dual to the perpetual inventory method could be used to measure the price of capital services. The price of capital is equal to the sum of the nominal returns to capital $P_{A,t-1}r_t$ and depreciation δP_t:

$$P_{Kt} = P_{A,t-1} r_t + \delta P_{At} \tag{A.3}$$

Given data on property compensation, the stock of assets, the price of investment goods and the rate of depreciation the rate of return can be determined. The rate of return can be expressed as:

$$r_t = \frac{P_{K,t}A_{t-1} - \delta P_{A,t}A_{t-1}}{P_{A,t-1}A_{t-1}} \tag{A.5}$$

Data on rates of depreciation for all farm assets were provided by Dr. Dale Jorgenson. The depreciation rates used for the various assets are as follows: farm tractors, .1452; agricultural machinery, .1179; trucks, buses and truck trailers, .2537; automobiles, .3333; and farm structures, .0237.

The data on investments in automobiles, farm tractors and agricultural machinery was taken from United States Department of Agriculture, Income and Balance Sheet Statistics (1990). The Producer Price indices used as deflators for the investment data were obtained from the United States Department of Commerce, Bureau of Labor Statistics (1960-1989). Estimates of investment in non-residential structures are obtained from USDA Statistical Bulletin no. 831 (1990). Benchmark figures for investment in real estate and machinery are also taken from USDA

Statistical Bulletin no. 831 (1990). As with the Canadian data capital gains were excluded in calculating service prices for capital. In addition animal capital was excluded from the measure of capital to maintain consistency between the two databases. Finally, the value of capital services was computed as the product of the rental price and the quantity of capital in the preceding period. Tornqvist's price and implicit quantity indices were constructed for real estate and machinery using the data developed via the perpetual inventory method.

Consumer Price Index and Per Capita Gross National Product

The Gross Domestic Product and Consumer Price Index figures used in the construction of instruments in estimation for excluded demand variables were obtained from the International Monetary Fund, International Financial Statistics (1980, 1990). The population figures were taken from the United Nations Department of International Economic and Social Affairs, Monthly Bulletin of Statistics (1965-1990). This data was used to construct estimates of Real Per Capita Gross Domestic Product and aggregate consumer expenditures, which were used as instruments in estimating the United States model.

REFERENCES

Aizcorbe, A.C., C. Winston, and A. Friedlaender. "Cost Competitiveness of the U.S. Automobile Industry." In Blind Intersection? Policy and the Automobile Industry. ed. C. Winston. Washington D.C.: Brooking Institute, 1987.

Amemiya, T., "The Maximum Likelihood and the Nonlinear Three Stage Least Squares Estimator in The general Nonlinear Simultaneous Equation Model." Econometrica, Vol 45, No. 4, (1977): 955-966.

Applelbaum, E., and J. Berechman. "Demand Conditions, Regulation and the Measurement of Productivity." Journal of Econometrics, Vol. 47, (1991): 379-400.

Azizul, I., "Comparative Advantage in Bangladesh." Ph.D. dissertation, Boston University, 1980.

Balassa, B., "Recent Developments in the Competitiveness of American Industry and Prospects for the Future." In Factors Affecting the U.S Balance of Payments, Subcommitte on International Exchange and Payments, Joint Committee of the Congress, 1962.

Balassa, B., "An Empirical demonstration of Classical Comparative Costs Theory". Review of Economics and Statistics, Vol. 45, No. 4, (1963): 259-266.

Balassa, B., "Trade Liberalization and Revealed Comparative Advantage." Manchester School of Economic and Social Studies, Vol. 33, No. 2, (1965): 99-123.

Balassa, B., and D.M. Schydlowsky. "Effective Tariffs, Domestic Resource Cost of Foreign Exchange and the Equilibrium Exchange Rate." Journal of Political Economy, Vol. 76, No. 4, (1968): 348-60.

Ball, V.E., "Output, Input, and Productivity Measurement in U.S Agriculture, 1948-1979." American Journal of Agricultural Economics, Vol. 67, (1985): 475-86.

Ball, E.V., "Modelling Supply Response in a Multiproduct Framework". American Journal of Agricultural Economics, Vol. 70, (1988): 813-825.

Bauer, P.W., "Decomposing TFP Growth in the Presence of Cost Inefficiency, Non constant Returns to Scale, and Technological Progress." Journal of Productivity Analysis, Vol. 1, (1990): 287-299.

Berndt, E., and M. Fuss. "Productivity Measurement with Adjustments for Variations in Capacity Utilization and Other Forms of Temporary Equilibrium". Journal of Econometrics, Vol. 33, (1986): 7-29.

Berndt E.R., and D.M. Hesse. "Measuring and Assessing Capacity Utilization in the Manufacturing Sectors of Nine O.E.C.D. Countries." European Economic Review, Vol. 30, (1986): 961-989.

Bernhardt, I., "Sources of Productivity Differences Among Canadian Manufacturing Industries." Review of Economics and Statistics, Vol. 63, No. 4, (1981): 503-512.

Bhagwati, J., "The Pure Theory of International Trade: A Survey." Economic Journal, 74 (1964): 1-82.

Binswanger, H.P., "A Cost Function Approach to the Measurement of Factor Demand Elasticities and Elasticities of Substitution." American Journal of Agricultural Economics, Vol. 56, (1974): 377-384.

Blandford, D., "The Costs of Agricultural Protection and the Difference Free Trade Would Make." In Agricultural Protectionism in the Industrialized World, ed. F. H. Sanderson, Washington, D.C.: Resources for the Future, (1990): 398-432.

Boggio, L., and P. Tirelli. "Economic Growth, Exports and International Competitiveness." Economic Journal, Vol. 42, (1989): 24-46.

Brinkman, G., "The Competitive Position of Canadian Agriculture". Canadian Journal of Agricultural Economics, Vol. 35, No. 2, (1987): 263-288.

Brinkman, G.L., and B.E. Prentice. "Multi-factor Productivity in Canadian Agriculture: An Analysis of Methodology and Performance 1961-1980." Development Policy Directorate, Regional Development Branch, Agriculture Canada, Ottawa, 1983.

Brown, R.S., and L.R. Christensen "Estimating Elasticities of Substitution in a Model of Partial Static Equilibrium: An Application to U.S Agriculture, 1947-1974." In Modelling and Measuring Natural Resource Substitution. eds., E. Berndt and B. Field. Cambridge, Mass.: MIT Press, 1981: 210-229.

Brundy, J., and D. Jorgenson. "Efficient Estimation of Simultaneous Equations By Instrumental Variables." Review of Economics and Statistics, Vol. 53, No. 3, (1971): 207-254.

Bruno, M., "The Optimal Selection of Export Promoting and Import Substituting Projects." In Planning the External Sector. New York: United Nations, 1967: 88-135.

Bruno, M., "Duality, Intermediate Inputs and Value Added." In Production Economics: A Dual Approach to Theory and Applications, Vol. 1. eds., M. Fuss and D. McFadden. Amsterdam: North-Holland Publishing Company, 1978: 3-16.

Capalbo, S.M., "Measuring the Components of Aggregate Productivity Growth in U.S Agriculture." Western Journal of Agricultural Economics, July (1988): 53-61.

Capalbo, S.M., and J.M. Antle. Agricultural Productivity Measurement and Explanation. Washington, D.C.: Resources for the Future, (1988).

Capalbo, S.M., and M.S Denny. "Testing Long-Run Productivity Models for the Canadian and U.S Agricultural Sectors". American Journal of Agricultural Economics, Vol. 68, (1986): 615-625.

Chambers, R.G., Applied Production Analysis. Cambridge: Cambridge University Press, 1988.

Christensen, L.R., and D.W. Jorgenson. "The Measurement of U.S. Real Capital Input, 1929-1967." Review of Income and Wealth, Vol. 15, No. 4, (1969): 293-320.

Conrad, K., "Productivity and Cost Gaps in Manufacturing Industries in U.S., Japan and Germany." European Economic Review, Vol. 33, (1989): 1135-1159.

Conrad, K., and R. Unger. "Productivity Gaps and Capacity Utilization in the Manufacturing Sector of Five O.E.C.D. Countries, 1963-1982." Journal of Productivity Analysis, Vol.1, (1989): 101-122.

Crandall, W.R., The U.S Steel Industry in Recurrent Crisis: Policy Options in a Competitive World. Washington, D.C.: Brookings Institution, 1981.

Diewert. W.E., "Applications of Duality Theory." In Frontiers of Quantitative Economics, Vol. II. ed., D. Kendrick. Amsterdam: North-Holland Publishing Company, 1974: 106-171.

Diewert, W.E., "Exact and Superlative Index Numbers." Journal of Econometrics, Vol. 4, (1976): 115-145.

Diewert, W.E., "Hicks' Aggregation Theorem and the Existence of a Real Value Added Function.", In Production Economics: A Dual Approach to Theory and Applications, Vol. 1. eds., M. Fuss., and D. McFadden. Amsterdam: North-Holland Publishing Company, 1978: 17-51.

Dogramaci, A., "Perspectives on Productivity." In Productivity Analysis: A Range of Perspectives. ed. A. Dogramaci. Boston: Martinus Nijhoff Publishing, 1981: 1-23.

Durand, M., and C. Giorno. "Indicators of International Competitiveness: Conceptual Aspects and Evaluation." OECD-Economic-Studies, Vol. 0, No. 9, (1990): 147-182.

Erickson, D., and H. Guither, "Agricultural Policies of the United States and Canada: Implications for Trade." In Agricultural Trade Between the United States and Canada, Washington, D.C., National Public Policy Education Committee, 1986.

Ezaki. M., and D.W. Jorgenson. "Measurement of Macroeconomic Performance in Japan 1951-1968." In Economic Growth: The Japanese Experience Since the Meiji Era, Vol. 1. eds., K Ohkawa and Y. Hayami. Tokyo: Japan Economic Research Center, 1973: 286-361.

Fagerberg, J., "International Competitiveness." Economic Journal, Vol. 98, (1988): 355-373.

Featherston, M., "Manufacturing Export Shares and Cost Competitiveness of Advanced Industrial Countries." Economic Policy Review, Vol. 3, March (1977): 87-99.

Freshwater, D., "Farm Finance and the Public Sector: A Macroeconomic Perspective." Canadian Journal of Agricultural Economics, Vol. 35, No. 4, 1987: 709-733.

Friedlaender A.F., C. Winston, and K. Wang. "Costs, Technology and Productivity in the U.S. Automobile Industry." Bell Journal of Economics, 14 (1983): 1-20.

Fuss, M., and D. McFadden. Production Economics: A Dual Approach to Theory and Applications, Vol. 1. Amsterdam: North-Holland Publishing Company, 1978.

Fuss, M., and L. Waverman. "Multi-Product Multi-Input Cost Functions for a Regulated Utility: The Case of Telecommunications In Canada." In Studies in Public Regulation. ed., G. Fromm. Cambridge Mass.: MIT Press, (1981): 265-313.

Gallant, R.A., and D.W. Jorgenson "Statistical Inference for a System of Simultaneous, Non-Linear, Implicit Equations in the Context of Instrumental Variable Estimation." Journal of Econometrics, Vol. 11, (1979): 275-302.

Gardner, B., "United States."In Agricultural Protectionism in the Industrialized World. ed. F. H. Sanderson. Washington, D.C.: Resources for the Future, (1990): 19-63.

Gorman, W.M., "Measuring the Quantities of Fixed Factors." In Value Capital and Growth: Papers in Honor of Sir John Hicks. ed., M. Gorman. Chicago: Aldine Publishing Company, 1968: 126-173.

Greene, W.H., Econometric Analysis. New York: Macmillan Publishing Company, 1990.

Griliches, Z., "Research Expenditures, Education and the Aggregate Agricultural Production Function." American Economic Review, Vol. 54, (1964): 961-974.

Harriss, L., "Basic Forces in Productivity Growth." In Productivity Analysis: A Range of Perspectives. ed. A. Dogramaci. Boston: Martinus Nijhoff Publishing, 1981: 39-48.

Helpman, E. "International Trade in the Presence of Product Differentiation, Economics of Scale and Monopolistic Competition: A Chamberlain-Heckscher-Ohlin Approach." Journal of International Economics, Vol. 11, (1981): 305-340.

Helpman, E., and P.R. Krugman., Market Structures and Foreign Trade: Increasing Returns, International Competition and the International Economy. Cambridge, Mass.: MIT Press, 1985.

Hicks, J., Essays in World Economics. Oxford: Clarendon Press, 1959.

Hotelling, H., "Edgeworth's Taxation Paradox and the Nature of Demand and Supply Functions." Journal of Political Economy, 40 (1932): 577-616.

Hulten, C.R., "Productivity Change, Capacity Utilization, and the Source of Efficiency Growth." Journal of Econometrics, Vol. 33, (1986): 31-50.

International Monetary Fund., International Financial Statistics. Author, New York, 1960-1990.

Islam, S., "Currency Misalignment: the Case of the Dollar and the Yen." Quarterly Review, Federal Bank of New York, Vol. 8, No. 4, (1983): 49-60.

Islam, T.S., "Input Substitution and Productivity Change in Canadian Agriculture." Ph.D. Dissertation, University of Alberta, 1982.

Johnson, H., Economic Development and International Trade. Cambridge: Cambridge University Press, 1968.

Jorgenson, D., "The Economic Theory of Replacement and Depreciation." In Econometrics and Economic Theory, ed., W. Sellekaerts. New York: McMillan and Company, 1974: 189-221.

Jorgenson, D.W., and M. Nishimizu. "U.S and Japanese Economic Growth, 1952-1974: An International Comparison." Economic Journal, Vol. 88, (1978): 707-726.

Josling, T., F. Sanderson, and T. Waley. "The Future of International Agricultural Relations: Issues in the GATT Negotiations." In Agricultural Protectionism in the Industrialized World. ed., F.H. Sanderson, Washington, D.C.: Resources for the Future, 1990: 433-464.

Judge, G.G., W.E. Griffiths, R.C. Hill, and T. Lee. Theory and Practice of Econometrics. New York: John Wiley and Sons, Inc., 1980.

Junz, B.H., and R. Rhomberg. Prices and Export Performance. Proceeding of the Business and Economic Statistical Section, American Statistical Association, 1964.

Keese, M., The Measurement of Output and Factors of Production for the Business Sector in OECD Countries: The OECD Business Sector Database. Paris:. Organisation for Economic Co-operation and Development, (1991).

Kellerman, M., "Relative Prices and International Competitiveness: an Empirical Investigation." Empirical Economics, Vol. 8, No. 3-4, (1983): 125-138.

Kendrick, W.J., Understanding Productivity. An Introduction to the Dynamics of Productivity Change. Baltimore: John Hopkins University Press, 1977.

Kilpatrick, J.A., and R.R Miller. "Determinants of the Commodity Composition of the U.S Trade: A Discriminant Analysis Approach." Journal of International Business Studies, Vol. 11, No. 1, (1978): 25-32.

Kravis, B.I., "A Survey of International Comparisons of Productivity." Economic Journal, Vol. 86, (1976): 1-44.

Kruger, A., "Some Economic Costs of Exchange Control: The Turkish Case." Journal of Political Economy, Vol. 86, (1966): 466-480.

Kruger, A., and B. Tuncer. "An Empirical test of the Infant Industry Argument." American Economic Review, Vol. 72, No. 2, (1982): 1142-1152.

Krugman, P.R., "Increasing Returns, Monopolistic Competition, and Internal Trade." Journal of International Economics, Vol. 9, (1979): 469-479.

Krugman, P., "Intra-Industry Specialization and the Gains from Trade." Journal of Political Economy, Vol. 89, (1981): 959-973.

Krugman, P., "The Narrow Moving Band, the Dutch Disease, and the Competitive Consequences of Mrs. Thatcher." Journal of Development Economics, Vol. 27, (1987): 41-55.

Lancaster, K., "Intra-Industry Trade under Perfect Monopolistic Competition." Journal of International Economics, Vol. 10, (1980): 151-175.

Langham, M., and I. Ahmad. "Measuring Productivity in Economic Growth." American Journal of Agricultural Economics, Vol. 65, (1983): 445-451.

Lau, L.J., "A Characterization of the Normalized Restricted Profit Function." Journal of Economic Theory, Vol. 12, (1976): 131-163.

Lau, L.J., "On Exact Index Numbers." Review of Economics and Statistics, Vol. 61, No. 32, (1979): 73-82.

Leisner, T., One Hundred Years of Economic Statistics: United Kingdom, United States of America, Australia, Canada, France, Germany, Italy, Sweden. New York: The Economist Publications, (1989).

Lopez, R.E., "The Structure of Production and the Derived Demand for Inputs in Canadian Agriculture." American Journal of Agricultural Economics, Vol. 62, (1980): 38-45.

Lopez, R.E., "Estimating Substitution and Expansion Effects Using a Profit Function Framework." American Journal of Agricultural Economics, Vol. 66, (1984): 358-367.

Lopez, R.E., and T. Fu-Lai "Energy and Non-Energy Input Substitution Possibilities and Output Scale Effects in Canadian Agriculture." Canadian Journal of Agricultural Economics, Vol. 30, No. 2, (1982): 115-132.

Lucas, R., "On the Theory of DRC Criteria." Boston University, Economics Department, Unpublished Paper, 1981.

Lundberg, E., "Productivity and Structural Change - A Policy Issue in Sweden." Economic Journal, Vol. 82, (1988): 465-485.

MacDougall, G.D.A., "British and American Exports: A Study Suggested by the Theory of Comparative Costs." Economic Journal, Vol. 62, (1951): 697-698.

Mansfield, E., Statistical Cost Functions. New York: W.W. Norton and Company, 1982.

McCulloch, R., "Trade Deficits, Industrial Competitiveness and the Japanese." In International Trade and Finance Readings. eds. R. Baldwin., and D. Richardson. Boston: Little Brown and Company, 1986: 19-35.

McFadden, D., "Cost, Revenue and Profit Functions." In Production Economics: A Dual Approach to Theory and Applications, Vol. 2. eds. M. Fuss and D. McFadden. Amsterdam: North-Holland Publishing Company, 1978: 3-46.

McGeehan, M.J., "Competitiveness: A Survey of Recent Literature." Economic Journal, Vol. 78, (1968): 243-262.

McGregor, P.G., and J.K. Swales. "Professor Thirlwall and Balance of Payments Constrained Growth." Applied Economics, Vol. 17, No. 1, (1985): 17-32.

Meekhof, R.L., "Implications of Increased Reliance on International Markets." In Structural Issues of American Agriculture., U.S.D.A, Economics, Statistics, and Cooperatives Service. Agricultural Economic Report 438. Nov 1979.

Meilke, K.D., and T.K. Warley "Canada." In Agricultural Protectionism in the Industrialized World, ed. F. H. Sanderson, Washington, D.C.: Resources for the Future, (1990): 112-180.

Morici, P., The Global Competitive Struggle: Challenges to the United States and Canada. Washington: Canadian-American Committee, 1984.

Morrison, C.J., "Productivity Measurement with Non-Static Expectations and Varying Capacity Utilization." Journal of Econometrics, Vol. 33, (1986): 51-74.

Nelson, R.R., "Research on Productivity Growth and Productivity Differences: Dead Ends and New Departures." Journal of Economic Literature, Vol. 19, (1981): 1029-1064.

Nishimizu, M., and J.M. Page. "Productivity Change and Dynamic Comparative Advantage." Review of Economics and Statistics, Vol. 68, No. 2, (1986): 241-247.

Norton, G., and J. Davis. "Evaluating Returns to Agricultural Research: A Review ." American Journal of Agricultural Economics, Vol. 63, (1981): 685-699.

Organisation for Economic Co-operation and Development., Recent Developments in Canadian Agricultural Policy. Author, Paris, (1978).

Ohta, M., "A Note on the Duality between Production and Cost Functions: Rate of Returns to Scale and Rates of Technical progress." Economic Studies Quarterly, Vol. 25, (1974): 63-65.

Oleson, B.T., "World Grain Trade: An Economic Perspective of the Current Price War." Canadian Journal of Agricultural Economics, Vol. 35, No. 3, (1987): 501-504.

Ostry, S., and P.S. Rao. "Productivity Trends in Canada." In Lagging Productivity Growth: Causes and Remedies. eds., S. Maital and N. Meltz. Cambridge, Mass.: Ballinger Publishing Company, 1980: 39-75.

Pack, H., "Productivity and Technical Choice. Applications to the Technical Industry." Journal of Development Economics, Vol. 16, No. 1-2, (1984): 153-176.

Paul, S., "Competitiveness of Exports:A Micro-Level Approach." Economic Journal, Vol. 80, (1970): 895-909.

Porter, M.E., The Competitive Advantage of Nations. New York: The Free Press Inc., 1990.

Rao, P,S., "Comparison of the Production and Cost Performance of Canada and U.S Industries". Working Paper ., Economic Council of Canada, Forthcoming.

Rao, P.S., and R.S. Preston. "Inter-Factor Substitution, Economies of Scale and Technical Change: Evidence from Canadian Industries." Empirical Economics, Vol. 9, No. 2, (1984): 87-111.

Ray, C.S., "A Translog Cost Function Analysis of U.S Agriculture, 1939-77." American Journal of Agricultural Economics, Vol.64, (1982): 490-498.

Ray, F.G., "Export Competitiveness: British Experience in Eastern Europe." National Institute Economic Review, Vol. 12, No. 5, (1966): 34-78.

Ruttan, V., "Agricultural Research and the Future of American Agriculture." In The Future of America as a Strategic Resource. eds., S.S Batie and R. Healy. Washington, D.C.: The Conservation Foundation, 1980.

Samuelson, P.A., Foundations of Economic Analysis. Cambridge, Mass.: Harvard University Press, 1947.

Schankerman, M., and M. Nadiri. "A Test of Static Equilibrium Models and Rates of Return to Quasi-fixed Factors, with an application to the Bell System." Journal of Econometric, Vol. 33, (1986):97-118.

Scherer, M.F., "The Determinants of Industrial Plant Sizes in Six Nations." Review of Economic Statistics, Vol. 55, No. 2, (1973): 135-145.

Shen, T.Y., "Competition Technology and Market Shares." Review of Economics and Statistics, Vol. 48, No. 1, (1970): 96-102.

Shumway, C., "Models and Methods Used to Allocate Resources in Agricultural Research: A critical Review." In Resource Allocation and Productivity in Natural and International Agricultural Research, ed. T.M. Arndt, D. Dalrympia, and V.W. Ruttan, Minneapolis: University of Minnesota Press, 1977.

Srinivasan, J.N., and Bhagwati, J. "Shadow Prices for Project Selection in the Presence of Distortions: Effective Rates of Protection and Domestic Resource Costs." Journal of Political Economy, Vol. 86, (1978): 97-116.

Statistics Canada., Farm Wages in Canada. Cat. No. 21-002. Ottawa., Annual.

Stern, R.M., and Maskus. K. "Determinants of the Structure of U.S Foreign Trade, 1958-76." Journal of International Economics, Vol. 11, (1981): 207-224.

Sudit, P., "The Role of Comparative Productivity Accounting in Export Decisions." Journal of International Business Studies, Vol. 15, No. 1, (1984): 105-118.

Tange, L., "Trade Frictions and Productivity Performance - Technological, Price and Cost Competitiveness of Japan and U.S Exports." Journal of Policy Modelling, Vol. 5, No. 3, (1983): 313-331.

Taylor, T.G., and N. Kalaitzandonakes., "A Test of Assets Fixity in Southeastern U.S. Agriculture." Southern Journal of Agricultural Economics, Vol. 22, No. 1, (1990): 105-111.

Taylor, T.G., and R.L. Kilmer., "An Analysis of Market Structure and Pricing in the Florida Celery Industry." Southern Journal of Agricultural Economics, Dec., Vol. 20, No. 2, (1988): 35-43.

Thirlwall, A.P. "The Balance of Payment Constraint as an Explanation of International Growth Rate Differences." Banca Nazionale Del Lavoro Quarterly Review, 32(1979): 45-54.

Thirlwall, A.P., "Balance of Payments Constrained Growth: A Reply to McGregor and Swales." Applied Economics, Vol. 18, No. 12, (1986): 1259-1263.

Thompson, R., A Survey of Recent U.S. Developments in International Agricultural Trade Models. Washington: USDA, ERS, International Economics Division, 1981.

Toder, E.J., Trade Policy and the U.S. Automobile Industry. New York: Praeger, 1978.

United Nations Department of Economic and Social Affairs., Monthly Bulletin of Statistics. Author, New York, 1965-1990.

United States Department of Agriculture., Desk Reference to U.S Agricultural Trade. Economic Research Service. Washington, D.C., 1991.

United States Department of Agriculture., Economic Indicators of the Farm Sector: Income and Balance Sheet Statistics. Economic Research Service. Washington, D.C., 1990.

United States Department of Agriculture., Farm Sector Balance Sheet, Including Operator Households, 1960-1989, and Excluding Operator Households, 1974-89: By Sales Class. Economic Research Service, Washington, D.C., 1990.

United States Department of Commerce., National Accounts Issue. Author, Washington, D.C., 1960-1989.

Uzawa, H., "Production Function with Constant Elasticity of Substitution." Review of Economic Studies, Vol. 24, No. 81, (1962): 291-299.

Vollrath, T., Revealed Competitiveness for Wheat. USDA, ERS, Washington, D.C., (1987).

Vollrath, T., "A Theoretical Evaluation of Alternative Trade Intensity Measures of Revealed Comparative Advantage." Weltwirtschaftliches Archiv Review of World Economics, Vol. 2, (1991): 265-280.

Vollrath, T., and D.H. Vo. "Investigating the Nature of World Agricultural Competitiveness." USDA, ERS, Technical Bulletin No.1754., 1988.

Warley, T., Agriculture in an Interdependent World: U.S and Canadian Perspectives. Washington: Canadian-American Committee, 1977.

White, L., The Automobile Industry Since 1945. Cambridge: Harvard University Press, 1971.

BIOGRAPHICAL SKETCH

Patrick A. Antoine was born on June 6, 1964, to Joyce and Alphonsus Antoine in St. George's, Grenada. He graduated from Jamaica College in 1980, and completed his secondary education in Grenada at the Institute for Further Education. He entered the University of the West Indies, Cave Hill Campus, Barbados in September 1984 and graduated with a B.Sc. (honors) in economics in 1987.

He returned to Grenada and worked as a researcher at the Grenada National Science and Technology Council, and as an economics teacher at the Institute for Further Education. In January 1988, he enrolled at the University of Florida and began the M.S. program at the Food and Resource Economics Department. The M.S. degree was awarded to him in August 1989.

Patrick continued his studies in the doctoral program of the Food and Resource Economics Department at the University of Florida. His doctoral degree was awarded in August of 1992.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Timothy G. Taylor, Chair
Professor of Food and
Resource Economics

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

James L. Seale, Jr.
Associate Professor of Food and
Resource Economics

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Gary F. Fairchild
Professor of Food and
Resource Economics

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Chris O. Andrew
Professor of Food and
Resource Economics

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Leonard K. Cheng

Leonard K. Cheng
Associate Professor of
Economics

This dissertation was submitted to the Graduate Faculty of the College of Agriculture and to the Graduate School and was accepted as partial fulfillment of the requirement of the degree of Doctor of Philosophy.

August, 1992

Jack L. Fry

Dean, College of Agriculture

Dean, Graduate School